

May 13th & 14th, 2002 Natcher Conference Center National Institutes of Health Bethesda, Maryland

Conference Proceedings

CONFERENCE PROGRAMME

The fMRI Experience IV

Welcome

The f_{MRI} Experience IV

May 13th & 14th, 2002

Natcher Conference Center

National Institutes of Health, Bethesda, Maryland, USA

In the summer of 1999, the fMRI Experience began as a meeting of around 100 people at the Institute of Psychiatry in London. Its purpose was to allow newcomers to functional neuroimaging the opportunity to present their work alongside luminaries in the field. Judging by the steady increase in delegates in the succeeding years, there is clearly a large demand for such an event. This year, the fourth annual fMRI Experience welcomes over 500 scientists to the National Institutes of Health campus in Bethesda, in what is being hailed as the largest teaching event ever organised by research fellows and hosted by the NIH.

This year the conference benefited enormously from three sources of financial assistance for delegates. This assistance took the form of competitive travel awards. The first of these awards is the fMRI experience prize, sponsored by the Laboratory of Brain and Cognition in the NIMH Intramural Research Program, and awarded to four delegates who were judged to have the potential for international leadership in the field. The Seymour Kety Travel Scholarship, sponsored by the NIMH Division of Intramural Training, was awarded to 19 delegates. The Institute of Psychiatry in London awarded a third group of conference travel awards. The organising committee would like to thank the outstanding generosity of these donors for helping allow as many people as possible to attend the fMRI Experience and for helping to make the conference such a success.

The Organising Committee

Carl Senior, Ph.D.

Laboratory of Brain and Cognition

National Institute of Mental Health, USA

Cynthia Fu, M.D. Section of Neuroimaging Institute of Psychiatry, London

Tamara Russell, Ph.D.
Section of Neuroscience and Emotion
Institute of Psychiatry, London

Michael Beauchamp, Ph.D.

Laboratory of Brain and Cognition

National Institute of Mental Health, USA

The Organizing Committee

would like to thank the following people for their support:

Peter Bandettini, Robert Desimone, James V. Haxby, Barry Kaplan, Alex Martin, Leslie Ungerleider & Margarita Valencia

Graphics & Media

Martha Blalock, Kyle Christiansen & Jim Daley

Abstract Reviewers

Jessica Gilbert, Michael Glabus, Alumit Ishai, Yang Jiang & Jill Weisberg

The Seymour Kety Scholarship Selection Committee

Robert Desimone, Yang Jiang, Barry Kaplan, Susan Koester & Luiz Pessoa

MRI Experience Prize Winners

Sponsored by The Laboratory of Brain & Cognition National Institute of Mental Health

Guosheng Ding

Department of Psychology Beijing Normal University, China

Belinda Liddell

Department of Psychology The University of Sydney, Australia

Mairead MacSweeney

Institute of Child Health University College London, UK

Nikolaus Kriegeskorte

Department of Psychology University of Maastricht, The Netherlands

The Seymour Kety Travel Scholarship

Sponsored By The Division of Intramural Research National Institute of Mental Health

Draulio de Araujo

Universidade de Sao Paulo, Brazil

Gabor Bajzik

University of Kaposvar, Hungary

Alice Hiu Dan Chan

The University of Hong Kong, China

Metehan Cicek

University of Ankara, Turkey

Martin Dobsik

St. Annes University Hospital, The Czech Republic

Alexander Fornito

The University of Melbourne, Australia

Melissa-Jayne Green

Macquarie University, Australia

Juan Hu

Peking University, China

Mateus Joffily

Federal University of Rio de Janeiro, Brazil

Magdalena Krupa-Kwiatkowski

San Diego State University, USA

Qian Luo

Beijing Normal University, China

Manas Mandal

Indian Institute of Technology, Kharagpur, India

Janiana Miranda

Federal University of Rio de Janeiro, Brazil

Leticia de Oliveira

Federal University of Rio de Janeiro, Brazil

Mirtes Gracia Pereira

Federal University of Rio de Janeiro, Brazil

Weiqun Song

Chinese Academy of Sciences, China

Savio Wong

The University of Hong Kong, China

Duo Xu

Beijing Normal University, China

JongJong Young

Peking University, China

The fMRI Experience Travel Awards

Sponsored by The Institute of Psychiatry, London

Nadine Gaab

Beth Israel Deaconess Medical Center & Harvard Medical School, USA

Neeltje van Haren

University Medical Center Utrecht, The Netherlands

Oleg Korzyukov

University of Helsinki, Finland

Jennifer Mandzia

University of Toronto & Sunnybrook, Women's Health Science Center, Canada

Aimee Nelson

University of Toronto & Sunnybrook, Women's Health Science Center, Canada

Tamar van Raalten

University Medical Center Utrecht, The Netherlands

Astrid van der Schot

University Medical Center Utrecht, The Netherlands

Simon Surgaladze

Institute of Psychiatry, London

Jim Thompson

Swinburne University of Technology, Australia

Kylie Wheaton

Swinburne University of Technology, Australia

CONFERENCE PROGRAMME

The fMRI Experience IV

Natcher Conference Center

National Institutes of Health

Bethesda, Maryland

United States of America

Monday, May 13th, 2002

0800-0900 Registration

Welcome & Introduction

0900-0915 The Organising Committee

FIRST SESSION

Physics, Methods & Signals

Chaired by: Dr. RASMUS BIRN & Dr. ZIAD SAAD

Unit on Functional Neuroimaging Methods Laboratory of Brain & Cognition and Scientific & Statistical Computing Core, NIMH, USA

0915-0945 Professor Steven C.R. Williams

Section of Neuroimaging Research Institute of Psychiatry, London

Physics, Pirouettes and Philosophers: A Primer on MRI Physics

0945-1015 Dr. Robert Cox

Scientific & Statistical Computing Core, NIMH, USA

Analysis of fMRI Data: Principles and Practice

I015-I045 Dr. Peter Bandettini

Unit on Functional Neuroimaging Methods Laboratory of Brain & Cognition, NIMH, USA

Are you fMRI experienced?

Morning Refreshment Break

Coffee will be served in the conference hall atrium.

SECOND SESSION

Sex, Lies & Audiotapes

(student presentations)

Chaired By: Dr. Leslie Ungerleider & Dr. Thalia Wheatley

Sections on Neurocircuitry & Cognitive Neuropsychology

Laboratory of Brain & Cognition, NIMH, USA

III5-II30 ALEXANDER SUMICH

Section of Cognitive Psychopharmacology

Institute of Psychiatry, London
Love and Lust in the Male Brain

1130-1145 DANIEL LANGLEBAN

Center for Studies of Addiction, University of Pennsylvania, USA

Functional Magnetic Resonance of Intentional Deception

1145-1200 Steven Brown

University of Texas Health Science Center, USA

The Neural Basis of Discriminating Melodic and Harmonic Sequences

as Compared to Discriminating the Meaning of Sentences

1200-1215 NADINE GAAB

Beth Israel Deaconess Medical Center & Harvard Medical School, USA

The Role of Posterior Perisylvian Regions in Pitch Memory:

An fMRI-study with Sparse Temporal Sampling

Lunch Break

First Poster Session & fMRI database demonstration will take place in the conference hall atrium.

1315-1345 Special Lecture

Imaging Mechanisms of Visual Attention By Dr. Leslie Ungerleider

Laboratory of Brain & Cognition, NIMH, USA

Chaired by: Dr. Tamara Russell

Section of Neuroscience & Emotion Institute of Psychiatry, London

THIRD SESSION

Meaning in Mind

(student presentations)

Chaired by: Dr. ALEX MARTIN & Dr. ELIZABETH HOFFMAN

Sections on Cognitive Neuropsychology & Functional Brain Imaging

Laboratory of Brain & Cognition, NIMH, USA

1345-1400 Guosheng Ding

Department of Psychology, Beijing Normal University, China Semantic Processing and Translation in the Chinese–English Bilingual Brain

I400-I4I5 Draulio de Araujo

Department of Physics & Mathematics, University of Sao Paulo, Brazil

Human Navigation, MEG and fMRI Results

1415-1430 AIMEE J. NELSON

Institute of Medical Science, University of Toronto, Canada

The Cortical Network Associated with Predictable and Unpredictable Visual Stimuli

I430-I445 JAMES C. THOMPSON

Brain Sciences Institute, Swinburne University of Technology, Australia

Hemodynamic Responses in Humans to the Perception of Compatible and Incompatible Body Motion

Afternoon Refreshment Break

Tea will be served in the conference hall atrium.

FOURTH SESSION

Seeing Sounds, Smiles & Scenes

Chaired by: Dr. MICHAEL BEAUCHAMP & Dr. YANG JIANG

Section on Functional Brain Imaging, Laboratory of Brain & Cognition, NIMH, USA

1515-1545 Dr. Philip McGuire

Section of Neuroimaging, Institute of Psychiatry, London

Neural Correlates of Inner Speech, Auditory Imagery & Auditory Hallucinations

1545-1615 Dr. James V. Haxby

Section on Functional Brain Imaging

Laboratory of Brain & Cognition, NIMH, USA

The Functional Neuroanatomy of the Human Face Processing System

1615-1645 Professor Rainer Goebel

Department of Neurocognition, University of Maastrict, The Netherlands

Tracking the Mind's Image in the Brain

Tuesday, May 14th, 2002

FIRST SESSION

Language, Thought & Representation

Chaired by: JILL WEISBERG & DR. LUIZ PESSOA

Sections on Cognitive Neuropsychology & Neurocircuitry

Laboratory of Brain & Cognition, NIMH, USA

0900-0930 Dr. Alex Martin

Section on Cognitive Neuropsychology

Laboratory of Brain & Cognition, NIMH, USA

Objects, Concepts and the Brain

0930-1000 Professor Helen Neville

Institute of Neuroscience, University of Oregon, USA

Specificity and Plasticity in Human Brain Development

1000-1030 Professor Giacomo Rizzolatti

Institute of Human Physiology, University of Parma, Italy

The Mirror System: A Mechanism for Understanding the Actions of Other Individuals

Morning Refreshment Break

Coffee will be served in the conference hall atrium.

SECOND SESSION

Beyond Functional Modularity

(student presentations)

Chaired by: Dr. James V. Haxby & Dr. Hauke Heekeren

Sections on Functional Brain Imaging, Functional Imaging Methods and Neurocircuitry, Laboratory of Brain & Cognition, NIMH, USA

1100-1115 Nikolaus Kriegeskorte

University of Maastricht, The Netherlands

Information-based Multivariate Functional Brain Mapping

III5-II30 ALUMIT ISHAI

Section of Neurocircuitry, Laboratory of Brain & Cognition, NIMH, USA Visual Imagery of Famous Faces: Effects of Memory and Attention Revealed by fMRI

1130-1145 DAVID COX

The Rowland Institute for Science, Cambridge, USA fMRI "Brain Reading:" A Statistical Pattern Recognition Approach to

fMRI Imaging of Visual Object Recognition and Imagery

I 145-1200 Janaina Mourão Miranda

Brazilian Academy of Sciences, University of Rio de Janeiro, Brazil Unpleasant Pictures Induce Coupling between Amygdala and Visual Areas

Lunch Break

Second Poster Session will take place in the conference hall atrium.

I300-I330 Special Lecture

Genetic Variation and fMRI Response By Dr. Daniel Weinberger

Clinical Brain Disorders Branch, NIMH, USA

Chaired by: Dr. CYNTHIA FU

Section of Neuroimaging, Institute of Psychiatry, London

THIRD SESSION

Abnormal Cognition

(student presentations)

Chaired by: Dr. VINCENT WALSH & Dr. ALUMIT ISHAI

Experimental Psychology, Oxford University, UK and

Section on Neurocircuitry, Laboratory of Brain & Cognition, NIMH, USA

1330-1345 MAIREAD MACSWEENEY

Institute of Child Health, London

Activation of Auditory Cortex by Visual Movement in Congenitally Profoundly Deaf People

1345-1400 Belinda Liddell

The University of Sydney, Australia

Disconnection of Arousal-Limbic-Frontal Networks in Schizophrenia?

I400-I4I5 JENNIFER MANDZIA

Sunnybrook & Women's College, University of Toronto, Canada fMRI Encoding and Retrieval in Normal Aging and Mild Cognitive Impairment

1415-1430 NICHOLAS WALSH

Neuroimaging Research Group, Institute of Psychiatry, London

An fMRI Investigation of Executive Function in Major Depression

Afternoon Refreshment Break
Tea will be served in the conference hall atrium.

FOURTH SESSION

New Approaches to the Study of the Mind

Chaired by: Dr. Patrick Bellgowan & Dr. Maura Furey

Unit on Functional Neuroimaging Methods

Laboratory of Brain & Cognition and Molecular Imaging Branch

Mood & Anxiety Disorders Program, NIMH, USA

1500-1530 Dr. Elizabeth Disbrow

Department of Neurology, University of California, Davis, USA

Functional Imaging in the Monkey Brain

1530-1600 Dr. Jack Van Horn

The National fMRI Data Center, Dartmouth College, USA

The fMRI Data Center: Developments and Directions

1600-1630 Dr. Vincent Walsh

Department of Experimental Psychology, University of Oxford, UK

Complementary Maps of the Mind: TMS and fMRI

1630-1700 Dr. Derek Jones

Department of Old Age Psychiatry, Institute of Psychiatry, London

DT-MRI — Is it going to help us?

1700-1705 Closing Remarks

POSTER PROGRAMME

The fMRI Experience IV

All posters will be on display in the conference hall atrium and presenters are asked to be by their posters during the lunch break.

Please set your posters up by the morning coffee break — adhesive material will be supplied.

Due to the limited number of boards, any posters that are left up over night will be removed and destroyed.

First Poster Session

Monday, May 13th, 2002

Psychopathology

I DIANNE ANDERSON

Brain Science Institute, Swinburne University of Technology, Melbourne, Australia Language Lateralization in Children with Cerebral Lesions Demonstrated by fMRI

2 Kuan Hua Kho

Departments of Neurosurgery & Psychiatry, University Medical Center Utrecht, The Netherlands Temporal Pole Activation during Language Processing: An fMRI Study in Epilepsy Patients Who are Candidates for Left Anterior Temporal Lobectomy

3 Melissa Lamar

National Institute on Aging, NIH, USA Orbital Frontal Aging: Evidence for Early Detection of Cognitive Changes Using fMRI

4 Galit Pelled

Hadassah Hebrew University Hospital, Jerusalem, Israel Reduced Sensorimotor Cortical-basal Activity in a Rat Model of Parkinson's Disease as Measured by fMRI

5 Moriah Thomason

Stanford University, USA

Reduced Neural Activation in Parkinson Disease: An Event-related fMRI Study of Processing Speed

6 BANU YAGMURLU

University of Ankara School of Medicine, Turkey Stereotactic Navigation with fMRI in Brain Tumors Adjacent to Motor Cortex

7 Silvia Arcuri

Section of Neuromaging, Institute of Psychiatry, UK

Differential Engagement of Inferior Frontal Cortex Associated with a Degrading Pattern of Executive
Functioning in Schizophrenic Patients with Thought Disorder

8 Kiki Chang

Stanford University, USA

fMRI of Emotional Processing in Pediatric Bipolar Disorder

9 Alexander Fornito

Department of Psychiatry, The University of Melbourne, Australia Surface Morphology of the Anterior Cingulate Cortex in Schizophrenia: Implications for Neuropsychological Test Performance

10 VENKATESHA MURTHY

Imperial College School of Medicine, London 'Imaging a Socially Unacceptable Image' Voxel-based Morphometry in Tardive Dyskinesia and Schizophrenia

II SIMON SURGALADZE

Section of Neuroscience & Emotion, Institute of Psychiatry, London, UK Why the sad face? Clinical Depression and the Overactive Brain

Cognition

12 ROBERT BITTNER

Department of Psychiatry, Johann Wolfgang Goethe-University, Germany Load Effects and Capacity Constraints in Visual Short-term Memory

13 Jean-Claude Dreher

Clinical Brain Disorders Branch, NIMH, USA

Dissociating the Roles of the Lateral Prefrontal and the Anterior Cingulate Cortex in Sequences of Decisions

14 Maike Heining

Section of Neuroscience & Emotion, Institute of Psychiatry, London, UK Disgusting Odours Activate Human Right Anterior Insula and Ventral Striatum

15 JOSEPH KABLE

Center for Cognitive Neuroscience, University of Pennsylvania, USA Neural Substrates of Verb Semantics

16 QIAN (JESSIE) LUO

Department of Psychology, Beijing Normal University, Beijing, China Comprehension of Metaphors in Chinese–English Bilinguals: An Event-related fMRI Study

17 Fumiko Maeda

UCLA Brain Mapping Center, USA Right Parietal Operculum and the Sense of Self

18 LINDA MAH

Cognitive Neuroscience Section, NINDS, USA An fMRI Study of Automatic Beliefs about Gender and Race

19 AIMEE J. NELSON

University of Toronto & Sunnybrook, Women's Health Science Center, Toronto Modulation of Cortical Activity Driven by Changes in Sensory Afference and Sensorimotor Transformations Measured via fMRI

20 Luiz Pessoa

Laboratory of Brain and Cognition, NIMH, USA
Neural Correlates of Visual Working Memory: BOLD Predicts Task Performance

21 Yulin Qin

Psychology Department, Carnegie Mellon University, USA

Event-related fMRI Study on the Effect of One Week-long Practice in Human Problem Solving

22 EVE STODDARD

Departments of Neurology and Radiology, Thomas Jefferson University Hospital, USA Brain Structures Responsive to Mastering A New Skill

23 TAMAR VAN RAALTEN

University Medical Center Utrecht, The Netherlands Automatization and Information Processing Capacity

24 MATTHIJS VINK

University Medical Center Utrecht, The Netherlands
Neural Correlates of Spatial Negative Priming: An Explorative fMRI Study

25 JILL WEISBERG

Laboratory of Brain and Cognition, NIMH, USA A Neural Substrate for Interpreting Social Interaction

26 SAVIO WONG

Laboratory for Language and Cognitive Neuroscience, Hong Kong University, China Cortical Processing of Chinese and English Words by Early Bilinguals

Second Poster Session

Tuesday, May 13th, 2002

Visual Cognition

I WEN-BIN GAO

Institute of Psychology, The Chinese Academy of Sciences, China Neural Mapping during Visual Search Precued by Different Size

2 Maria Ida Gobbini

Laboratory of Brain and Cognition, NIMH, USA

Altered Responses to Faces Due to Experimentally Induced Familiarity

3 Hauke R. Heekeren

Laboratory of Brain and Cognition, NIMH, USA
Non-monotonic fMRI Response to a Motion Discrimination Task in Human Area MT

4 YANG JIANG

Laboratory of Brain and Cognition, NIMH, USA Perceptual Convergence of Objects and Motion

5 Juan Hu

Department of Psychology and National Laboratory on Machine Perception Peking University, China The Context-dependent Effect of Hole Superiority in Human Pattern Recognition

6 SCOTT MOFFAT

National Institute on Aging, NIH, USA Functional Brain Activation during Navigation through Novel Versus Familiar Virtual Environments

7 DVORA PERETZ

Mathematics Department, Michigan State University, USA Externalizing Cognitive Processes — A Methodological Research Tool

8 Mathijs Raemaekers

University Medical Center Utrecht, The Netherlands
Brain Activation during Smooth Pursuit Eye Movements with Varying Luminance Contrasts

9 ZHENG SHEN

Department of Psychology and National Laboratory on Machine Perception Peking University, China The Hole Superiority Effect is Context Dependent in Monkey Pattern Recognition

10 KYLIE WHEATON

Brain Sciences Institute, Swinburne University of Technology, Melbourne, Australia Brain Regions Responsive to the Perception of Human Motion

II Duo Xu

Beijing Normal University, Beijing, China An fMRI Study of Speed Reading

Methods, Models & Machines

12 PATRICK BELLGOWAN

Laboratory of Brain and Cognition, NIMH, USA

Understanding Cognitive Processing Streams through Independent Estimates
of the Hemodynamic Magnitude, Onset Delay and Width

13 MATTHEW BELMONTE

McLean Hospital, USA

Handling Variations in Functional Anatomy Across Subjects: Computational and Analytical Methods Applied to the Study of Visual Spatial Attention

I4 Elisa Kapler

Laboratory of Brain and Cognition, NIMH, USA Modulation of the Hemodynamic Response Dynamics in the Hippocampus during a Novel Picture Task

15 Oleg Korzyukov

Cognitive Brain Research Unit, Department of Psychology, University of Helsinki The Influence of the Noise Induced by the fMRI Imager on the Electromagnetic Responses of the Human Brain during Selective Attention Task

16 Yousef Mazaheri

Medical College of Wisconsin, USA High Resolution fMRI with Half k-Space Interleaved Echo-Volume Imaging

17 Natalia Petridou

Laboratory of Brain and Cognition, NIMH, USA What is the Optimum Spatial Resolution for fMRI?

18 DAVID COX

The Rowland Institute for Science, Cambridge, USA Advances in Thermoplastic Head Restraint

19 AFONSO SILVA

Laboratory of Functional and Molecular Imaging, NINDS, USA Laminar Specificity of fMRI Onset Times during Somatosensory Stimulation

20 Keith St. Lawrence

Laboratory of Diagnostic Radiology Research, NIH, USA

Drug Effects on Oxidative Metabolism and Cerebral Blood Flow Changes in Sensorimotor Activation

21 ASTRID VAN DER SCHOT

University Medical Center Utrecht, The Netherlands
Short Echo Time fMRI, Mesiotemporal Tissue Signal and BOLD Sensitivity

22 Neeltje van Haren

Department of Psychiatry, University Medical Center Utrecht, The Netherlands Reliability of Brain Volume Estimations in a Multicenter MRI Study

ABSTRACTS

The fMRI Experience IV

fMRI of Emotional Processing in Pediatric Bipolar Disorder

Nancy Adleman, Kiki Chang, Venod Menon & Allan Reiss

Stanford University, USA

Introduction: There is little known regarding emotional processing in children and adolescents with bipolar disorder (BD). This study reports on fMRI findings of emotional processing in pediatric BD.

Methods: We recorded brain activation using fMRI during presentation of emotionally valenced visual stimuli (positive, negative, and neutral). Subjects were 9 children with BD (mean age 13.86) and 12 healthy controls (mean age 13.31).

Results: Bipolar subjects showed significantly (p < 0.05) greater activation than controls to negatively valenced stimuli in left dorsolateral prefrontal cortex, superior/medial frontal gyrus, superior, middle, and inferior temporal gyri, inferior parietal lobe, middle occipital gyrus, as well as in bilateral insula, and right parahippocampal gyrus and cuneus. In response to positive stimuli, bipolar subjects showed more activation than controls in left medial/superior frontal gyrus, thalamus, bilateral postcentral gyrus, and right posterior cingulate gyrus, precentral gyrus, and inferior parietal lobe. Controls did not show significantly greater activation than the bipolar subjects in any region.

Conclusions: Children with BD demonstrate an increased amount of brain activity when viewing negatively and positively valenced stimuli. Increased brain activation in children with BD may reflect an increased reactivity and/or susceptibility to emotional stimuli, or the utilization of abnormal neural circuits in children with BD.

Language Lateralization in Children with Cerebral Lesions Demonstrated by fMRI

Dianne Anderson, A. Simon Harvey, David Abbott, Vicki Anderson & Michael Kean

Brain Science Institute, Swinburne University of Technology Brain Research Institute, Austin & Repatriation Medical Centre Royal Children's Hospital, Melbourne, Australia

Introduction: Language lateralization is an important consideration in planning neurosurgery. Timing of lesion and developmental versus acquired lesion aetiology have been suggested as important factors in provoking reorganization of language function. Developmental lesions are thought not to displace language cortex and lesions acquired prior to 5 years of age are likely to provoke contralateral transfer. This study aims to examine the feasibility of language lateralization with fMRI in a large group of children with cerebral lesions and consider issues of plasticity of language function.

Methods: Thirty-five children and adolescents (8 to 18 years) with cerebral lesions involving either the frontal or temporal lobe referred for language lateralization (21 right handed). Thirty had left hemisphere lesions with 3 also having a lesser degree of right hemisphere pathology. Ten of these patients had lesions involving the left inferior frontal region specifically. Five children had lesions confined to the right hemisphere. Thirty-one subjects had a history of seizures. Eleven lesions were acquired post-natally, prior to 13 years of age; four encephalopathy, two stroke, four hippocampal atrophy, and one neoplastic tumour. Pre-natal aetiology included 14 dysplasias, eight developmental tumours, and two pre-natal ischaemia. FSIQ of the group ranged form intellectually disabled to above average.

The activation paradigm was an orthographic lexical retrieval task with six repetitions of 36s task and 36s rest. Multi-slice fMR imaging (single-shot EPI, TR=5s, TE=60ms, I28xI28matrix, FOV=250xI80mm, slice thickness=4mm, gap=3-6mm, I.5T GE Echo-Speed scanner) was performed at 4 or 6 coronal slice positions, centered on Broca's area, and 4 or 6 axial slice positions through the frontal and parietal lobes in the plane of the Sylvian fissure. Using iBrain, ^{®2} images were smoothed to 3.9mmFWHM, total intensities of within brain voxels were normalized and t-test statistical maps comparing task and rest at each voxel location were created using a threshold Bonferroni corrected for multiple comparisons.

Quantitative lateralization indices (LI) were calculated for activation in the inferior frontal region on the coronal studies. LI greater than absolute 0.5 were considered to indicate strong lateralization and between 0.25 and 0.5 were regarded as weakly lateralized.

Results: Inferior frontal activation was demonstrated in all but three children and was left lateralized in 24 patients. Five patients were right lateralized and three patients showed bilateral activation. All patients with right hemisphere lesions had left language lateralization. Of the ten patients with lesions involving the left inferior frontal region, five were left lateralized, three were right lateralized and two had bilateral language activation. Each of these lateralization subgroups included one child with a lesion acquired after the age of 5 years.

Conclusions: Lateralization of language function is possible using an OLR activation paradigm in children as young as 8 years of age with a variety of cerebral lesions and intellectual capabilities. Our data indicate that prediction of language lateralization in children with cerebral lesions is not straightforward and as such fMRI language lateralization is likely to be a useful tool in surgical planning.

References

¹Duchowny M, et al. Ann Neurol 1996;40:31-38.

²Abbot D, Jackson G. Neuroimage 2001;13(6):S59.

Human Navigation, MEG and fMRI: Preliminary Results

Draulio de Araujo

Department of Physics and Mathematics University of Sao Paulo, Brazil

Introduction: The involvement of Rhythmical Slow Activity (Theta) and spatial memory has long been investigated in rats. Recently, human intracranial electrodes measurements showed the appearance of 4-7 Hz oscillations in a variety of cortical regions, and suggested their possible relation to navigation tasks.

Method: Here we investigate alpha and theta activity while subjects navigated through a virtual reality environment using a 74 channel first order gradiometers system (BTi - MAGNES II). Using a mouse to navigate through a virtual reality town, they were first allowed to explore the entire environment on their own. MEG was then recorded before and while each subject navigated from a starting place to a specific destination. In the next set of trials, routes were blocked, forcing the subjects to take alternative pathways. Spatiotemporal analysis of theta and alpha band was used to study their involvement with navigation tasks.

Results: It was observed that during navigation theta activity increased while alpha oscillations decreased. Although the amplitude variation of theta was consistent with effect of concentration on Frontal Midline Theta Activity $(Fm\theta)$, the spatial character is different.

Conclusions: These results suggest a possible association between theta rhythm and performance of navigation task in humans. As a complementary study we are using fMRI to investigate spatial patterns associated with the same paradigm. The data is being collected using a Siemens scanner (Magneton Vision, I.5 Tesla) from the University Hospital. The images are being analyzed by software developed by our group that uses the standard statistical methods, such as the student t-test.

Differential Engagement of Inferior Frontal Cortex Associated with a Degrading Pattern of Executive Functioning in Schizophrenic Patients with Thought Disorder

Silvia Arcuri, Matthew Broome, Edson Amaro, Michael Brammer, Robin G. Morris & Philips McGuire

Section of Neuromaging, Brain Imaging Analysis Unit Clinical Neuropsychology Unit, Institute of Psychiatry University of London, UK

Introduction: The specific neural and cognitive correlates of Thought Disorder in Schizophrenia are largely unknown. Cognitive models suggest that TD is associated with hyperactivation of the semantic network and with impairments in executive functions (Spitzer, 1997, Goldberg, 1998), while neuroimaging studies suggest that classic language areas are involved (Kircher et al., 2001).

Methods: Semantic processing of sentences and executive functions (EF) were examined in 20 healthy controls, 21 schizophrenic patients with thought disorder (TD) and 19 without thought disorder (NTD). Semantic processing was examined employing the effects of semantic constraint on the processing of sentences with a paradigm derived from the N400 component of ERP. EF were assessed with tasks measuring verbal and visuo-spatial working memory and strategy formation as well as attentional set shifting, sequencing and cognitive estimation. Half of this sample was also examined in an event-related FMRI task that involved deciding the semantic appropriateness of sentence's final words (Arcuri et al., 1999).

Results: Behavioral data: Schizophrenic patients showed robust impairments in EF which were more pronounced in those with higher TD scores (Arcuri et al., 2001). These results were further corroborated by analysis of the speech production of TD in a sentence completion task (modified Hayling Test) which showed impairments of its executive aspects as measured by inhibition and formation of strategy (Arcuri et al., 2001a). There was no evidence of hyperactivation of the semantic network in any of the groups.

FMRI data: In the Left Inferior Frontal Cortex (IFC) NTD patients showed greater activation than controls, who in turn showed greater activation than patients with TD. Only the NTD group showed activation in the right IFC. There were also clear differences in temporal lobe (TL) activation: controls activated the left TL more than TD, whereas TD activated the right TL more than NTD and controls. NTD activated the right TL more than controls (Arcuri et al., 2001b). There were also striking differences in the engagement of retrosplenial cortex.

Conclusions: Our findings suggest that Thought Disorder is associated with impaired executive control of language processing. In particular, TD was associated with reduced engagement of the Left inferior frontal cortex. The increased engagement of the prefrontal and temporal cortex that was evident in patients who did not have TD may be related to their relatively normal task performance.

Are You fMRI Experienced?

Peter Bandettini

Unit on Functional Neuroimaging Methods, Laboratory of Brain & Cognition National Institute of Mental Health, USA

What does it mean to be an expert in fMRI? It means having a deep understanding of the issues and bringing that understanding to bear for every step of the experimental process. It means knowing the tradeoffs, the best and latest applications, and using that knowledge to innovate so that the question asked is tailored to the unique advantages and limitations of fMRI. Bringing it all together requires experience with fMRI: hours of brainstorming over the right paradigm design, wrestling with the scanner hardware and pulse sequences, and the stimulus delivery and/or subject feedback systems, and then days digging into the data, trying to discern real signal from artifact. In this presentation I will outline the thought process of the experienced fMRI practitioner as a guide, a caution, and perhaps a motivation. In general, fMRI is a rapidly changing, highly complicated, and highly integrative type of research. The skills necessary are broad. The ways to do incorrect fMRI research are many, but so are the opportunities for well thought out, insightful experiments.

The variables that the experienced fMRI practitioner keeps in mind are listed below. In this presentation, I will briefly explain each of the variables and give an example of the difference between an experienced and inexperienced users approach in regard to each.

- I. The experimental hypothesis
- 2. Scanner variables

Hardware

Pulse sequences

Image quality

3. Physiologic variables

Neurovascular coupling

Contrast in fMRI: BOLD, flow, volume, CMRO2

Hemodynamic magnitude, latency, linearity and variability

4. Subject interface variables

Hardware

Stabilization

Stimulus/Feedback Scanner Synchronization

Neuronal input strategies

5. Processing steps and variables

Image reconstruction

Time series analysis

Data collapsing and pooling

Display

Understanding Cognitive Processing Streams through Independent Estimates of the Hemodynamic Magnitude, Onset Delay and Width

Patrick Bellgowan, Ziad Saad, Elisa Kapler & Peter Bandettini

Laboratory of Brain & Cognition National Institute of Mental Health, USA

Introduction: Models used for estimating hemodynamic onset delays can confound the relationship between hemodynamic response delay and response width. Width measures may reflect increased processing time in activated areas resulting in delayed activation (i.e., increased latencies) of downstream regions in serial neural systems. In the present study we present a model for obtaining independent estimates of both the hemodynamic response onset delay and width. This model is then applied to the analysis of a task involving reaction time delays due to stimulus rotation and lexical processing. It is hypothesized that rotation of words increases time dedicated to perceptual processing and delays the onset of activation in lexical processing areas.

Method: Three subjects performed a lexical decision task comprised of words and pronounceable non-words rotated at either 0o, 600,120o. Forty stimuli of each type were presented for 750 ms followed by a fixation crosshair. The average ISI was 3000 ms. FMRI Methods and Analyses: Four scans of 384 echo-planar images using a TR of 1000 ms and fourteen 6mm non-contiguous sagittal slices were collected in a randomized event-related design, concatenated, motion corrected, and deconvolved to obtain an impulse response function for each condition. The Full Model F-statistic from the deconvolution procedure was used to restrict the hemodynamic characterization analyses to those voxels that were significant, under any condition, at the p < 0.01 level. Delays were calculated by obtaining an average impulse response function (IRF) for each condition and fitting that average to a Gamma-variate model. An independent estimate of the width of the resultant IRF Gamma-variate model was accomplished by convolving it with a series of heavy-side functions varying in width. A least squares fit of the modeled response to the masked dataset of IRFs was conducted on a voxel-wise basis. Regions of interest (ROI) were selected relating to neural systems involved in either rotation or word processing and were defined using thresholded data obtained from the *a priori* general linear test conducted during deconvolution. The averaged time-series presented below were extracted from each ROI.

Results: Subjects performed well in all tasks. Stimulus rotation of 1200 increased reaction time an average of 879 ms. Figure Ia depicts increased magnitude and width of activation for the rotated stimuli in motor cortex. Figures Ib depicts a widening of the IRF in the parietal lobe in response to stimulus rotation of 1200 relative to 600. The widening may reflect increased processing related to stimulus rotation. Figure Ic shows a delayed onset to rotated stimuli in superior temporal gyrus (STG). This delay suggests that the STG cannot process written words until resolution of stimulus orientation has occurred in perceptual areas.

Conclusion: Results show that through independent estimation of hemodynamic response width and onset delay, areas involved in prolonged processing will show increased width. Regions dependent upon the completion of processing will show delayed hemodynamic onset times.

Handling Variations in Functional Anatomy Across Subjects: Computational and Analytical Methods Applied to the Study of Visual Spatial Attention

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Introduction: The resolution of functional maps derived from fMRI is limited not only by the spatial resolution and signal-to-noise tradeoff of the scanning hardware, but also by individual variations in functional neuroanatomy. Cortical regions subserving attention and executive control manifest a high degree of such variation, making already weak cognitive activations difficult to detect in spatially averaged brains. Detailed study of cognitive brain activation requires the development of computational methods and analytical techniques robust to anatomical variations across subjects.

Methods: In order to account for individual anatomical variation, we adopt a two-phase strategy in which statistically independent analyses are used first to establish functional maps within individuals and then to examine the effect of a task manipulation on activations within these maps. The first of these analyses compares activation during a cognitive task to activation at rest, while the second contrasts different levels or factors of this cognitive task within regions of interest defined on the basis of individual subjects' functional maps and local anatomical landmarks. To avoid the spatial blurring associated with parametric mapping, we base these analyses on permutation testing, a procedure for which we have developed an optimised, computationally feasible algorithm. Because permutation testing accounts for spatial correlations, it offers greater statistical power than standard parametric tests corrected for multiple comparisons.

Results: We have applied this strategy in a study of posterior attentional systems in normal subjects and in autistic patients, using visual spatial attention shifting as the task of interest, and left-field versus right-field attention as the within-task factors. In eleven normal subjects, we identified regions associated with visual spatial attention in an area of ventral occipital cortex centred on fusiform and lingual gyri contralateral to the attended hemifield (p < 0.006), and in the posterior extent of intraparietal sulcus ipsilateral to the attended hemifield (p < 0.009). Within the normal subjects there was a trend for a greater effect of hemifield in ventral occipital cortex and a lesser effect in intraparietal sulcus in males as compared to females. A comparison sample of six autism patients showed an absence of the occipital effect (p < 0.03) and a heightened intraparietal effect (p < 0.04).

Conclusion: Our finding of lateralised activation of ventral occipital cortex by visual spatial attention replicates previous fMRI and PET results. Lateralised intraparietal activation is a new finding, notable both because of its ipsilateral rather than contralateral focus and also because of its subtlety: the effect was manifest only when data from individually mapped regions of interest were pooled across subjects. We suggest that while ventral occipital cortex is active during early attentional enhancement of relevant stimuli, intraparietal cortex is associated with a later, complementary process of suppression of irrelevant stimuli. This intraparietal finding demonstrates the sensitivity of our two-stage approach using individual functional mapping and non-parametric statistical analysis.

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References

MK Belmonte, DA Yurgelun-Todd, IEEE Transactions on Medical Imaging 20(3):243-248 (2001).

MK Belmonte, DA Yurgelun-Todd, Society for Neuroscience Abstracts 27 (2001). 372(6506):543-546 (1994).

SA Hillyard, H Hinrichs, C Tempelmann, ST Morgan, JC Hansen, H Scheich, H-J Heinze, Human Brain Mapping 5(4):287-292 (1997). E Wojciulik, N Kanwisher, Neuron 23(4):747-764 (1999).

Load Effects and Capacity Constraints in Visual Short-term Memory

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Introduction: The functional neuroanatomy of visual short-term memory in humans has been studied extensively. In addition to revealing cortical areas participating in visual short-term memory, event-related fMRI allows for an investigation of the temporal dynamics and possible correlates of capacity constraints, which might have implications for neuropsychiatric disorders accompanied by impaired short-term memory.

Methods: Twelve subjects were scanned while performing a delayed discrimination task on abstract objects that did not allow for easy verbalization. The number of objects was parametrically varied between one and four. fMRI was recorded at high temporal resolution (Siemens Magnetom Vision, I.5 Tesla, 8 slices covering the frontal and parietal lobes, TR=Is). Data analysis was performed with the BrainVoyager 4.4 software package. Statistical analysis was based on the general linear model of the experiment for group data. Time courses of activated areas were analyzed by event related averaging of the four load conditions (only correct trials were used).

Results: Analysis of variance (ANOVA) revealed a significant main effect of load on reaction time and accuracy (p<0.05). Accuracy was significantly reduced in each load condition with respect to the conditions of lower load (with the exception of load one compared to load two), while reaction times increased with load, but differences reached significance level only between load one and each of the higher load conditions. During encoding, all three conditions of higher load (2 to 4) were accompanied by significantly higher activation than load one bilaterally in higher visual areas, including the inferior temporal cortex (IT) and the intraparietal sulcus (IPS) regions, frontal areas, including the middle frontal gyri, the precentral sulcus region and mesial superior frontal cortex. During delay, no significant departure from baseline activity was observed for load one in any of the scanned areas. All higher load conditions showed significantly greater activity than load one in the left inferior frontal gyrus, the middle frontal gyri and precentral sulcus regions bilaterally, the anterior IPS region bilaterally, and the left posterior IPS (with the activity of load three being significantly higher than that for load two). However, while the prefrontal areas showed a monotonic increase in the load three and four conditions (with the activation for load four being non-significantly higher than that for load three), BOLD signal in the parietal delay areas showed a reverse trend and was significantly lower for load four than load three.

Conclusions: Our results point to a clear difference in the pattern of cortical activation for the encoding and maintenance of single vs. multiple objects. They confirm the importance of prefrontal and parietal areas for the short-term storage of visual information. Additionally a double dissociation between frontal and parietal areas for high load conditions was observed. This double dissociation might be a physiological correlate of memory capacity constraints, perhaps reflecting a change of maintenance-strategy as memory load increases.

Advances in Thermoplastic Head Restraint

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Introduction: Edward and colleagues (Human Brain Mapping, II:207-213; 2000) reported the development and use of a whole-head plaster cast-based head restraint system that has shown great promise in limiting subject head motion and in allowing for repositioning of a subject's head across multiple sessions. Inspired by this work, we have developed a whole-head thermoplastic head restraint system that incorporates many of the advantages of a plaster-based system, while greatly simplifying the process of creation and adjustability of the system. In addition to dramatically limiting the range of possible movement of the head, the system also provides a great deal of tactile feedback to help the subjects limit their head movements. The mask is clamped to a specially designed cradle which fixes the subjects in a standard position relative to the head coil. This cradle is bolted to the patient table, thereby stabilizing the headcoil as well.

The system uses two sheets of a themoplastic material (such as is routinely used for head stabilization in external beam radiation therapy procedures) which are custom-molded to the front and back of the subject's head, forming a whole-head mask. This head restraint system has received approval from the Massachusetts General Hospital Institutional Review Board. A quick release mechanism allows subjects to remove themselves from the scanner in an emergency. In subjects tested so far (all relatively young and thoroughly screened for claustrophobia), all have found the system to be tolerable, and in some cases subjects have even reported that the system was more comfortable than the standard pillow used, since the custom-molded restraint provides more uniform head and neck support.

Method: We have collected data using the head restraint system with normal adults and it represents exceptionally small head movement within individual runs (of a few minutes), across many imaging runs (in the course of a 2 hour session) and across sessions (i.e., across several days with the same subject). Data collected across multiple sessions did not require the usual repositioning and calibration of head position: the head restraint system repositioned the subject to within a mm or two across imaging sessions, so functional data collection could begin almost instantly (specifically, within 3 minutes of placing the subject in the scanner).

Results: This data was collected with normal, well-motivated subjects; collaborators in the context of other research projects have secured IRB approval to repeat this work with stroke patients. Additionally, we are applying for IRB approval to repeat the work with children. Given that we have previously received permission to use the trickier and arguably more invasive bitebar head restraint system, we do not anticipate any problem with securing IRB approval to use the face mask with children.

The system was developed for a Siemens Allegra 3T head-only imager. Support for this work came from the Rowland Institute for Science; the Massachusetts General Hospital NMR Center; and the Athinoula A. Martinos Center for Functional and Structural Biomedical Imaging.

fMRI "Brain Reading:" A Statistical Pattern Recognition Approach to fMR Imaging of Visual Object Recognition and Imagery

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Introduction: Multivariate statistical pattern recognition methods, including Linear Discriminant Analysis and Support Vector Machines, were used to classify patterns of fMRI activation evoked by the visual presentation and cued imagery of various categories of complex real-world objects. Classifiers were trained using patterns of fMRI data across voxels within independently chosen ROIs in visual cortex. These classifiers were used to guess which category of object a subject was looking at, or imagining, in subsequent sessions on a block-by-block basis, using only 20 seconds of data at a time.

Methods: Whole-brain EPI data were collected using a 3Tesla Siemens Allegra head-only MR scanner (3.125 x 3.125 mm in-plane, 5 mm thick, TR=2sec), using a custom-designed thermoplastic head-restraint system which permits repeatable head position across sessions (within ~Imm). Stimuli were black-and-white photographs of objects belonging to ten different categories. Some categories were very different (e.g., teapots versus African Masks) and some very similar (e.g. cows versus horses). Each category of object was presented in 20 sec. blocks (ten stimuli displayed for 2 seconds each). In one variant, subjects were cued to imagine objects of a given category during each 20 second block, instead of seeing those objects. Data from each block were averaged across the duration of the block, and data from a subset of voxels in the brain were given to the classifiers. A variety of feature selection methods were tried for selecting interesting subsets of the voxels for subsequent analysis, drawing on both anatomical and functional information.

Results: Though the highest classification accuracies (81 percent accuracy for a ten-way discrimination) were obtained using patterns of activity in ROIs including lower visual areas, classification accuracies well above chance (40 percent accuracy; chance would be I0 percent, $p < 10^{-32}$) were achieved using ROIs restricted to "object-sensitive regions" (defined by significantly greater response to pictures than scrambled pictures of objects). Classifiers trained on data acquired during one session were equally accurate in classifying data collected within the same session and across sessions separated by more than a week, in the same subject. For imagined objects, accuracies of up to 37 percent (chance would be I0 percent) were obtained in ventral extrastriate areas, while no voxels in early visual cortex met the criteria for ROI selection.

SVM classifiers uniformly outperformed linear discriminant classifiers, which scaled poorly with increasing dimensionality. SVMs using nonlinear kernel functions (e.g., polynomial & radial basis functions) tended to outperform linear classification methods, suggesting that patterns of fMRI activity explored here may not be fully linearly separable.

Conclusions: Statistical pattern recognition approaches to fMRI data have many inherent advantages. They are naturally suited to the study of arbitrarily many classes of arbitrarily high-dimensional patterns of activity and they require no assumptions about the distribution, independence, or linearity of data. In addition, they provide a means for placing lower bounds on the information content of the fMRI-data associated with a specific brain region with respect to a given discrimination, and thus can help guide explorations of the organization of high-dimensional representational spaces.

Analysis of FMRI Data: Principles and Practice

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Data analysis always takes place in the context of a mathematical and statistical model for the relationship between the observations (the numbers in the images) and the desired information (the location, timing, of neural activity). FMRI data analysis is complicated by the facts that the relationship between neurophysiology and the observable NMR signal is only partially understood, and that different experimental designs interact with different aspects of the data-physiology relationship. As a result, FMRI data analysis is not now, nor is it likely to be, a stereotyped activity that can be packaged up into a "black box that does everything" software package. Instead, the neuroscientist must have some understanding of the physics, physiology, and mathematics/statistics of the signal and noise in order to pick the tools to use, to know when existing tools are inadequate, and to guide the development of new tools when needed.

The most common models used for fMRI activation mapping are built on the assumptions of small rigid 3D head movements by the subject, and the existence of a fixed (possibly unknown, possible spatially variable) linear shift-invariant relationship between the neural activity and the MRI signal changes. These models and tools that use them will be outlined in this talk.

Semantic Processing and Translation in Chinese— English Bilinguals Brain: An fMRI Study

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Introduction: Brain-imaging techniques such as PET and fMRI have been used to investigate the question of the organization and processing of language in the bilingual brain. In this research we addressed the neural mechanism of semantic processing and translation by using fMRI.

Method: Two tasks were set for the participants. The first was a semantic task, where participants decided if two words alternatively displayed in two conditions were synonyms. In the first 'within language' condition (WL condition), both the stimuli were two Chinese single-character words; while in the second 'cross language' condition (CL condition), only one Chinese word and one English word were presented. The second task involved translation and here the participants were asked to judge the perceptual feature of the counterpart word corresponding to the stimulus in different languages. In C2E condition, the stimulus was a Chinese word (e.g., ['BED']). The participants were asked to judge if the first letter of its translation word was "B"(in this case, the answer was "YES"). In E2C condition, the stimulus was an English word (for example, 'RIVER'). The participants needed to judge if its translation word in Chinese included a radical (in this case, the answer was "YES"). Twelve participants (6 male and 6 female) were scanned on a 2.0 tesla MRI scanner from the No.306People's Liberation Army Hospital. Scan Parameters: T2(EPI): TR/TE =3s/65; FOV:240mm X 240 mm; image matrix: 64X64X12; TI: FOV;240mmX240mm; image matrix: 256X256X60. All data were analyzed with AFNI(Analysis of Functional Neuroimages).

Results: In the semantic task activation patterns were very similar for the two conditions (WL and CL). However, direct contrast didn't show any significant difference. In the translation task, the activation patterns of C2E and E2C were significantly different. The C2E condition activated the bilateral prefrontal area (BA I0), while E2C activated the left posterior middle temporal gyrus/fusiform gyrus. It suggests that LI (the first language) and L2 (the second language) in Chinese-English bilinguals' brain share a common semantic storage system, but the translation processing between two languages is asymmetrical. LI -> L2 may involve more controlled processing while L2 -> LI is more automatic.

Conclusion: The pattern of brain activation in the semantic task is similar across languages, which suggests there is a common neural mechanism underlying both semantic processing of LI and that of L2. Whilst in the translation task, brain activation in C2E was quite different from that in the E2C condition.

Functional Imaging in the Monkey Brain

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In recent years an effort has been made to use functional MRI in non-human primates. Two slightly different approaches have been developed, one in anesthetized and one in awake behaving monkeys. The rise of the non-human primate imaging model facilitates several exciting lines of research. The monkey model can be used to examine the efficacy of imaging techniques or to aid in the interpretation of imaging results through study of the relationship between the blood oxygenation level dependent signal and underlying electrophysiological events. Another related area of interest is the extension of our understanding of human brain function through a combination of invasive and non-invasive study techniques. Performing neuroanatomical examinations of cortical connections, and electrophysiological recording experiments in combination with imaging studies yields a wealth of data for comparison with results from imaging studies in humans using identical stimuli. The results from the neuroanatomical and electrophysiological recording experiments can be used to guide the generation of testable hypotheses for the imaging studies and vice versa. These points will be illustrated using results from several labs doing non-human primate imaging to examine the BOLD signal, as well as our recent work on the cortical organization, connectivity and function of higher order somatosensory fields.

Dissociating the Roles of the Lateral Prefrontal and the Anterior Cingulate Cortex in Sequences of Decisions

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Introduction: The lateral prefrontal cortex is often coactivated with the anterior cingulate cortex in control demanding tasks. Although recent dissociations have been reported between these two regions in cognitive control, their respective functions remain unclear. The lateral prefrontal cortex is known to be essential during inhibition of motor sequences (go/no-go), while the anterior cingulate cortex is known to be involved in motor initiation. Based on these findings in the motor domain, we tested whether a similar dissociation would be present in the cognitive domain, when subjects perform sequences of decisions based on cognitive rules. We designed a new event-related fMRI task switching study to investigate whether the lateral prefrontal cortex and the anterior cingulate are respectively involved in overcoming the inhibition of a previously performed task and in initiating a new task.

Methods: Fourteen subjects performed three different letter discriminations tasks (vowel/consonant, lower/upper case, before/after "m" in the alphabet), cued by the color of the letter. Single letters were successively presented in triplets interleaved by 5 or 9 s and constructed, unaware to the subjects, to vary task repetition, switching, and recency within the three-letter set (ABA, ABB, and ABC, where A, B, and C reflect task order within a triplet, and can indicate any of the three tasks). Data were analyzed using SPM99 (random effect, P<0.00I, uncorrected). We focus on (I) the contrast between the third task of the ABA triplet and the third task of the ABC triplet to identify brain regions activated with overcoming inhibition and (2) the contrast between the first task and the second task to identify brain regions involved in reengaging in a sequence of task.

Results: Confirming a previous behavioral study, we found that switching to a recently performed task, that is likely to remain inhibited from its previous performance, increased the RTs as compared to switching to a task that was performed less recently [F(1,13)=10.0, P<0.01]. This inhibition concerned the cognitive, and not the motor level, because no interaction was found between motor priming (repetition of the same response) and the backward inhibition effect. Furthermore, behavioral data showed a main effect of position in the triplet [F(2,26)=19.8, P<0.0001], that is, the first task of a triplet induced slower response times (RTs) than the second task and the third task. These two behavioral effects were accompanied by a double dissociation in the prefrontal cortex, that was confirmed by a ROI analysis.

Conclusions: The right ventro-lateral prefrontal cortex (BA 45) was more active when switching to a task that has recently been performed, consistent with a role in overcoming the remaining inhibition of this previously performed task. In contrast, the anterior cingulate cortex (BA 32) was more active for the first task of each triplet, suggesting that it exerts a transient form of control. These results indicate that the lateral prefrontal cortex is involved in cognitive inhibition and suggests that the cingulate activation can reflect a general attention orienting function.

¹Mayr U et al., J Exp Psychol Gen 129:4-26, 2000.

Surface Morphology of the Anterior Cingulate Cortex in Schizophrenia: Implications for Neuropsychological Test Performance

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Introduction: We recently used structural MRI to examine sulcal/gyral morphology of the anterior cingulate cortex (ACC), and found that patients with schizophrenia display an absence of the normal leftward asymmetry in cortical folding of this region. In a subsequent PET study, we also found that, in contrast to controls, patients failed to activate the left paracingulate cortex during Stroop task performance, which supports the notion of a left-sided anomaly in the ACC of schizophrenia patients, and is consistent with the postulate that differences in sulcal/gyral patterns have functional significance. The present study aimed to further investigate the relationship between ACC structure and function in schizophrenia. Patients were administered two neuropsychological tests that increase in difficulty, given evidence that paracingulate activity is related to increased cognitive load. As the anomalies in this region are left-lateralised, it was expected that patients without this anomaly (i.e., those displaying the normative leftward asymmetry) would demonstrate better test performance, and less of a performance decrement at more difficult task levels, than patients with either a rightward asymmetric or symmetric pattern.

Method: ACC surface morphology was examined using a previously established method with structural MR images obtained from 37 healthy controls and 37 patients with established schizophrenia or schizophreniform psychosis All subjects were male and right-handed. Neuropsychological performance differences between these groups were compared on the computerised Tower of London (TOL), and Spatial Working Memory test (SWM) taken from the Cambridge Automated Neuropsychological Test Battery (CANTAB). These tests were chosen primarily because they both have levels of increasing difficulty while tapping different cognitive domains.

Results: Controlling for age, pre-morbid IQ and illness duration, there was a significant main effect of ACC morphological asymmetry on SWM performance, such that both patients and controls with leftward asymmetric ACC folding committed less errors overall, and demonstrated reduced performance decrement as the task became more difficult, than the rightward asymmetric or symmetric participants. In contrast to controls, a similar pattern to that observed on the SWM was evident within the patient group on the TOL, whereby patients with a leftward asymmetry made fewer excess moves, and also showed reduced performance decrement with increasing difficulty, than did those with symmetric and rightward asymmetric ACC folding. These differences however, did not reach statistical significance.

Conclusions: The performance patterns observed across both tests were in the predicted direction, to the extent that patients with leftward asymmetric ACC folding demonstrated better overall performance, and reduced performance decrement with increasing difficulty, than rightward asymmetric or symmetric patients. These findings encourage further investigation since they are consistent with our previous functional imaging evidence indicating that differences in ACC morphology may be associated with the functional properties of this region. They also suggest that the left-lateralised anomaly of the ACC in schizophrenia may have neurobehavioural consequences. We are currently developing more elaborate methods for quantifying ACC morphology and relating these to a wider range of neuropsychological tasks, in order to further elucidate the relationship between brain structure and function in schizophrenia.

BOLD fMRI of Craving in Smokers Initiated by Cigarette Cues

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Introduction: People, places, and things previously associated with smoking acquire the ability to elicit desire for a cigarette in many smokers. This desire or craving for a cigarette can be so strong that individuals wishing to remain abstinent find themselves relapsing. This type of craving is separate from the craving elicted by an absence of the pharmacological effects of nicotine. Presently nicotine replacement therapy is the most effective antismoking medication available however, it's effectiveness appears to address nicotine (withdrawal-based) craving and not cue-induced craving. To aid smokers in remaining abstinent, medications that can treat both kinds of craving are necessary. Development of such medications requires a knowledge of the brain substrates underlying cue-induced craving. Nicotine and cocaine are both reinforcing psychoactive drugs with common primary and secondary (conditioned) neural substrates. Several labs, including our own, have observed activation to cues for cocaine in limbic and corticolimbic regions (orbitofrontal cortex, anterior cingulate, amygdala and insula). Thus, we hyothesized that cue-induced cigarette craving would mimic the results of the cocaine cue studies.

Methods: The present study utilized BOLD fMRI and smoking cues to characterize the brain substrates of cue-induced nicotine craving. Smokers (>15cigs/day) and a matched nonsmoking group (n=11/grp) were imaged while viewing smoking- and non-smoking-related videos. Both videos were designed to maintain interest however only the smoking video contained smoking cues (people smoking, cigarette close-ups, etc.) To reduce any effects due to craving carryover, all subjects watched the neutral video first, followed by the smoking video. All subjects were right-handed and were free from psychiatric or physical illness at the time of the scan. At 2 minute intervals throughout the videos subjects were asked to rate their desire for a cigarette. A six item questionnaire designed to assess subjective measures of craving was administered pre- and post each video. Images were realigned, coregistered, normalized and smoothed using SPM implemented in MatLab. Statistical parametric maps were generated and transformed to the unit normal distribution SPM{Z} and thresholded at P <.05.

Results: Smoking subjects reported craving induced by cues whereas nonsmokers did not. The imaging data showed that the brain response to nicotine cues selectively activates the ventromedial orbitofrontal cortex, the lateral orbitofrontal cortex, the insula and the temporal cortex.

Conclusions: Brain regions activated during the presentation of nicotine cues are similar to those activated in studies of cue-induced cocaine craving. Deficits in these regions may be partially responsible for some of the detrimental behaviors common to individuals afflicted with drug dependence. Particularly, the cue-induced activation of the orbitofrontal cortex, a region implicated in decision-making and behavioral inhibition may contribute to continued nicotine use or relapse despite the awareness that use may lead to future negative consequences.

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The Role of Posterior Perisylvian Regions in Pitch Memory: An fMRI-study with Sparse Temporal Sampling

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Introduction: The functional anatomy of pitch memory is not completely explored. It is unclear whether pitch memory in comparison to pitch perception involves primary and secondary auditory areas as well extra-temporal brain regions involved in memory functions. Auditory tasks in the fMRI environment have been regarded as challenging, since the MR scanner noise on one hand can interfere with the auditory stimulation and on the other hand can lead to a masking of the auditory response. In addition, the MR scanner noise itself could lead to brain activation which might interfere with the induced activation by the behavioral task.

Methods: To avoid auditory masking effects we used a method of sparse temporal sampling with an effective TR of 17 sec separating the scanning from the actual auditory stimulation. Eighteen right handed, mostly non-musical subjects listened to a sequence of 6-7 sine wave tones lasting approximately 4.5 seconds. In the pitch memory task subjects had to compare the last or second last tone with the first tone and make a decision whether these tones were same or different (using button pressures as response). In the pitch perception task subjects had to count the number of tones and then indicate to a visual prompt of "six" or "seven" whether this was "same (correct)" or "different (incorrect)." The baseline condition was a rest condition with alternating button presses after a visual prompt. Only one set of 24 axial slices (4x4x6mm voxel size) was acquired after each auditory stimulation with varying the delay times randomly over a 9 second interval. The fMRI data were analyzed with SPM99.

Results: Preliminary results indicate that (I) pitch perception involves primary and secondary auditory regions within the superior temporal gyrus as well as within the superior temporal sulcus, more on the left side than on the right side. (2) The functional anatomy of pitch memory involves additional prefrontal and superior parietal regions which are known to be involved in working memory and auditory storage functions. (3) The activation pattern showed a temporal course that first involved auditory regions and then prefrontal, parietal and cerebellar regions at the later timepoints. (4) By regressing performance on the pitch memory task with MR signal change, left more than right posterior perisylvian regions including the supramarginal gyrus became highly significant.

Conclusion: These data support a role of the supramarginal gyrus as an auditory memory storage region.

Neural Mapping during Visual Search Precued by Different Size

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Introduction: Our previous study (Luo et al., 2001, Cogn. Brain Res.) provided electrophysiological evidence that changes in the spatial scale of attention modulate neural activity in early visual cortical areas, and activate at least two temporally overlapping component processes during visual search. The paradigm was upgraded in the present experiment. The object is to compare the cortical mechanisms associated with the visual spatial attention directed by location cues and Chinese character cues using event-related potentials (ERPs) record.

Methods: Subjects were eleven healthy adults (mean age = 19) with normal vision. The visual stimuli were presented with the sequence as: background (300ms)-cue (300ms)-target (1200ms). There were two ISIs used between the cue and target: short (400-600 ms) and long (600-800 ms). In the Experiment I, the cue was a circle with black solid line. There were three cue sizes: small, medium and large. In the Experiment II, three black concentric circles were presented as background, their diameters were the same as the three cues used in the Experiment I. The cue was one of three Chinese characters 小 (small), 中 (medium) or 大 (large) respectively. The task of the subjects was to discriminate whether the target, which is the vertically oriented crescent's horns were pointing to the right or to the left. The electroencephalogram (EEG) was recorded from I28 scalp sites.

Results: There was no significant difference in the percentage correct between the two experiments under the same spatial attention scale. RT of experiment II was longer with short ISI and small, medium cue. The early ERP components (PI and NI) were analyzed. The anterosuperior NI amplitude elicited by cue in Experiment II was larger than that of the Experiment I. The inferoposterior PI latency of the Experiment II was longer than that of Experiment I, and anterosuperior NI was earlier than inferoposterior PI in Experiment II. Comparing the target evoked ERP, the inferoposterior PI and NI latency of Experiment II was longer than that of Experiment I, the inferoposterior P2 amplitude of Experiment II was larger than that of Experiment I.

Conclusions: The NI component of ERP at the frontal region reflects the processing process of Chinese character (Wei et al., 2001, NeuroReport). Our current result suggested that the processing of Chinese cue takes place at the higher level functional brain regions compared to processing the location cue. The later requires more resource in the earlier stage of cue process and less in the subsequent stage of the task.

Altered Responses to Faces Due to Experimentally Induced Familiarity

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Introduction: Familiarity alters the neural response to faces in regions associated with perceptual processing (e.g., the fusiform gyrus), as well as in regions associated with representing semantic knowledge about biographical information (anterior middle temporal and temporal pole) and processing the emotional and social valence of stimuli (e.g., amygdala). Here we examine whether experimentally induced familiarity, that involves learning no biographical information or emotional associations, selectively alters the response in the perceptual areas.

Methods: Responses to different faces and scrambled pictures were measured using BOLD contrast fMRI (gradient echo EPI, GE 3T scanner) during a one-back repetition detection task in an event-related design experiment. Seven subjects were studied in three sessions on separate days: fMRI on day I, behavioral training on day 2, and fMRI on day 3. From a pool of novel faces, three faces were selected randomly for each subject to become familiar with behavioral training. On day I, the neural response to the three "selected" faces, as well as to control faces and scrambled pictures, was measured with fMRI; on day 2, the selected faces were the object of a feature-face matching task, designed to induce detailed familiarity with all parts of each selected face; and on day 3, the neural response to the same three "selected" faces and new sets of control faces and scrambled pictures were measured again with fMRI. Each selected face was presented 96 times in each fMRI session. Two different sets of three unfamiliar control faces were presented with the same frequency in the day I and day 3 fMRI sessions, as well as two sets of 18 unfamiliar faces that were repeated only 8 times each.

Results: The analysis of fMRI results from day 3 showed a stronger response in the precuneus to the "selected," now familiar, faces than to the frequently-repeated, unfamiliar control faces, and a weaker response in the fusiform gyri, the intraparietal sulci, and the posterior middle frontal gyri. These differences were not seen in the same comparison in the same analysis of fMRI data from day I.

Conclusions: The increased response in the precuneus to faces after experimentally-induced familiarity is consistent with other studies implicating this region in processes for the retrieval of information and images from long-term memory. By contrast, the familiar "selected" faces evoked a weaker response in the ventral temporal regions associated with perceptual processing, which may reflect the development of a sparser encoding for these faces. Intraparietal and middle frontal regions participate in working memory. The weaker response to the "selected" faces in these regions may reflect how familiarity made it easier to hold these faces in working memory in this one-back repetition detection task. As expected, experimentally induced familiarity did not alter the response to faces in any of the areas that have been associated with processing the biographical information or emotional and social valence associated with familiar faces. This result suggests that the decreased amygdala response to personally familiar faces is associated with more than simple visual familiarity.

Tracking the Mind's Image in the Brain

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Mental imagery, the generation and manipulation of mental representations in the absence of sensory stimulation, is a core element of numerous cognitive processes. We investigated the cortical mechanisms underlying imagery and spatial analysis in the visual domain using event-related functional magnetic resonance imaging during the mental clock task. In this task, subjects are asked to imagine pairs of clock faces on the basis of acoustically presented times, to compare the mental images, and to report in which of the two faces the clock hands form the greater angle. The mental clock task thus involves auditory perception, the translation of the auditory information into mental representations that preserve the angular differences, the comparison of the angles, and a behavioral response. The measured functional time-series were analyzed using both multi-subject hypothesis-driven statistical parametric analysis and single-subject data-driven cortex-based independent component analysis (cbICA). In the parametric analysis, the spatio-temporal pattern of activation was estimated assuming an explicit statistical model of the experiment (GLM). In the cbICA, individual functional data sets were decomposed blindly into spatially independent cortical maps, each having an associated time-course. Since ICA does not make assumptions about the time-course of the hemodynamic response, we used the results of this analysis to confirm that the findings of the hypothesis-driven analysis were not biased by the choice of one specific model. Finally, for all the cortical regions that were activated during the task, we performed a trial-by-trial analysis of the hemodynamic responses (HRs) that allowed us to establish a link between behavior, as measured by RT, and brain activity, at the spatial and temporal scale of fMRI. With the hypothesis- and data-driven analysis, we traced the cortical activation from auditory perception to motor response and reveal a sequential activation of the left and right posterior parietal cortex suggesting that these regions perform distinct functions in this imagery task. This was confirmed by the trial-by-trial analysis of correlations between reaction time and onset, width, and amplitude of the hemodynamic response. These findings go beyond the identification of co-activated brain regions during a complex task and provide new constraints for models of sequential information processing and lateralization in the human brain.

The Functional Neuroanatomy of the Human Face Processing System

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Face perception, perhaps the most highly developed visual skill in humans, is mediated by a distributed neural system in humans that is comprised of multiple, bilateral regions. We propose a model for the organization of this system that emphasizes a distinction between the representation of invariant and changeable aspects of faces. The representation of invariant aspects of faces underlies the recognition of individuals, whereas the representation of changeable aspects of faces, such as eye gaze, expression, and lip movement, underlies the perception of information that facilitates social communication. The model is also hierarchical insofar as it is divided into a core system and an extended system. The core system is comprised of occipitotemporal regions in extrastriate visual cortex that mediate the visual analysis of faces. In the core system, the representation of invariant aspects is mediated more by the face-responsive region in the fusiform gyrus, whereas the representation of changeable aspects is mediated more by the face-responsive region in the superior temporal sulcus. The extended system is comprised of regions from neural systems for other cognitive functions that can be recruited to act in concert with the regions in the core system to extract meaning from faces.

Non-monotonic fMRI Response to a Motion Discrimination Task in Human Area MT

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Introduction: Neural correlates of perceptual decisions have been studied using random dot kinematograms (RDK) (Newsome et al., 1989). Typically, monkeys view a field of randomly moving dots with a variable fraction moving coherently and indicate the direction of motion. To use this paradigm to study perceptual decision-making processes in humans using fmri it is important to know how the degree of coherence modulates brain activity.

Methods: To address this issue we used a block-design fmri-study (3T GE Signa) in which subjects viewed an RDK display for Is and decided whether the stimulus was moving to the left or to the right. Coherence varied randomly from block to block (0 percent, 6.4 percent, 12.8 percent, 25.6 percent and 51.2 percent). MT was identified independently using a low contrast motion stimulus (LCMS).

Results: Behavioral data showed a typical sigmoid performance curve, with an 82 percent threshold of about 12 percent. The BOLD response in MT as a function of coherence was U-shaped, with a minimum at peri-threshold levels (12 percent). In a second block-design fmri-experiment, we tested whether the non-monotonic shape of the BOLD response was due to attentional effects. In addition to the RDK stimulus, the letters L and T where flashed rapidly (5Hz) at fixation. Before each block the subjects were cued to either do the letter (count the number of Ls or Ts, LETT) or the motion discrimination task (MOT). When subjects performed LETT the BOLD response in MT was smaller than during MOT. During both MOT and LETT, the shape of the BOLD response as a function of coherence was U-shaped, thus the non-monotonicity cannot be explained by attentional modulation.

Conclusions: Recent neuroimaging studies on the relationship between coherence and MT response have yielded conflicting results. Some authors reported linear increases in BOLD signal with stimulus coherence, while others found larger responses to incoherent motion or no difference. Our data are consistent with a recent study reporting that in anesthetized monkeys BOLD signal varied nonmonotonically as a function of noise in visual stimuli (Rainer et al., 2001). Since we have ruled out that this effect is due to attentional modulatory effects our results are consistent with a heterogeneous pooled neural response. At 0 percent coherence many weakly active neurons with different preferred directions cause a similar summed BOLD response as few highly active neurons at 51.2 percent tuned to that direction. At peri-threshold levels fewer weakly active and fewer highly active neurons cause a smaller summed BOLD response.

Disgusting Odours Activate Human Right Anterior Insula and Ventral Striatum

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Introduction: The anterior insula is involved in gustation and olfaction (Small et al., 1997). However, neuroimaging and neuropsychological studies have shown that the insula and the ventral striatum are also involved in the recognition of facial expressions of disgust (Phillips et al., 1998; Calder et al., 2001). Thus this region may be concerned more specifically with the analysis of disgusting tastes or odours. We hypothesized that the anterior insula would be activated specifically by disgusting odours. However, as the insula is part of the olfactory system per se, we also expected to observe a degree of insula activation in response to all odour categories (pleasant, unpleasant and disgusting).

Methods: We used functional magnetic resonance imaging (fMRI) to determine brain activity in two groups of eight healthy, male volunteers during the presentation of disgusting, pleasant, and unpleasant but not disgusting odours compared to fresh air. Every participant was exposed to disgusting odours and either pleasant (Group I) or unpleasant (Group 2) odours in two 5 min experiments, which followed an AB block design. Image Acquisition: In each of 14 near-axial planes (7mm thick, 0.7mm gap, in-plane resolution 3mm) T2*-weighted MR images (TE=40ms, TR=3000ms, theta=90degrees, I00 images/slice) depicting BOLD contrast were acquired over 5 minutes per experiment (GE Sigma I.5T Neurovascular system (General Electric, Milwaukee WI, USA), Maudsley Hospital, London). Data Analysis: Generic brain activation maps (GBAMs) depicting voxels with significant mean power of response. Clusters of activation in the insula were chosen and their mean activation level compared between conditions in a paired t-test.

Results: Results show differential insula activation in response to the three categories of odours, with right insula activation only in response to disgusting odours. However, activation in the left insula was demonstrated in response to all odours. Comparisons of the mean Sum of Squares Ratio (SSQ – analogous to a z score in parametric tests) values of the activated clusters of interest revealed significant differences within groups between conditions. A significant difference in the right anterior insula (Talairach coordinates of the centre of the cluster: x = 42, y = 20, z = -2) at a level of p = 0.05 was found when comparing activation in response to disgusting odours with activation in response to pleasant odours. Group 2 showed a significant difference in activation in response to disgusting odours as compared to unpleasant odours in the right striatum (Talairach coordinates of the centre of the cluster: x = 22, y = 10, z = 7) at a level of p = 0.01.

Conclusions: Previous studies (Calder et al., 2001) have shown activation of the anterior insula in response to disgusting visual stimuli, here we show that part of the anterior insula is involved in the processing of disgusting odours as well. These findings show that the right anterior insula is involved in the perception of disgust regardless of sensory modality—it forms a key component of the neural circuitry underlying this emotion.

References

Small, DM, Jones-Gotman, M, Zatorre, RJ, Petrides, M, Evans, AC. Flavor processing: more than the sum of its parts. *NeuroReport* 8, 3913-17 (1997).

Calder, AJ, Lawrence, AD & Young, AW. Neuropsychology of fear and loathing. *Nature Reviews Neuroscience* 2, 352-63 (2001). Phillips, ML, Young, AW. Scott, SK, Calder, AJ, Andrew, C, Giampietro, V, Williams, SCR, Bullmore, ET, Brammer, M, Gray, JA. Neural responses to facial and vocal expressions of fear and disgust. *Proceedings of the Royal Society London*, Series B 265, 1809-17 (1998).

The Context-dependent Effect of Hole Superiority in Human Pattern Recognition

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Introduction: Chen (1982) demonstrated hole superiority in the sameness-difference judgment of geometric figure pairs by human subjects. But we found the context dependent effect of hole superiority in monkey pattern recognition by discrimination task of pictures. In the present paper, we designed the sameness-difference judgment to the picture pairs of both the geometric figure and line-drawn face. We compared hole superiority in different context (geometric figures or line-drawn faces) and in different hole size.

Methods: Stimuli comprised of two series of pictures: geometric figures and line-drawn faces. The first series contained four figures which had the same luminous flux, including triangle, ellipse, triangle with an inner hole and ellipse with an inner hole. The second series had four line-drawn faces with different eyes that were the same as the correspondent geometric figures in the first series. In the two series of pictures, the ratios of the hole diameter to the ellipse diameter are different: 1:1.5,1:2,1:2.5,1:3. The pictures were displayed on screen in pairs that had either a difference in the shape of the features or the difference with hole or not within the features. Stimulus sequence began with a fix point in the centre of screen for 600ms, then picture pair in both sides of fix point for 10ms, the last were two black squares as mask for 300ms. Ten undergraduate students sat in the front of screen keeping 4 degree visual angle to the pictures and performed sameness-difference judgment to picture pairs.

Results: In the judgment to the geometric figures, the correct rate of judgment to shape different pairs is higher than that of hole different pairs whatever the hole size. In the judgment to the line-drawn faces, the correct rate of judgment to shape different pairs is higher than that of hole different pairs with the hole ratios of 1:2.5 and 1:3. But the correct rate of hole different pairs is higher when the ratio is 1:1.5 or 1:2. Therefore hole superiority only appears in line-drawn face recognition when hole size is larger (1:1.5 or 1:2).

Conclusion: The hole superiority effect is not only dependent on context but also on hole size in human subjects. Our results consist with data in our monkey experiment but different from Chen's results. We are recording ERPs data from the same paradigm of experiment in human subjects to further study its brain function dynamics.

Visual Imagery of Famous Faces: Effects of Memory and Attention Revealed by fMRI

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Introduction: Functional brain imaging studies have shown that visual perception and visual imagery share common neural substrates. The type of memory that mediates the generation of mental images, however, has not been addressed previously. Moreover, it is unclear whether selective attention to features of mental images enhances the activity during imagery. The purpose of this study was to investigate the neural mechanisms underlying visual imagery generated from short- and long-term memory (STM and LTM) and the effects of attention during imagery.

Methods: We used fMRI at 3T to measure changes in BOLD T2*-weighted MRI signal while nine subjects (five males, four females, mean age 27 yr.) performed perception and imagery tasks in a standard block design. In the perception condition, subjects passively viewed gray-scale photographs of contemporary celebrities (each presented for 4 sec), and during the perception-control condition they viewed scrambled pictures. In the imagery conditions, subjects were presented with famous names (0.5 sec) and instructed to generate vivid images of these faces (3.5 sec). During the imagery-control condition, subjects viewed letter strings (0.5 sec) followed by a black screen (3.5 sec). During imagery from STM, subjects were presented with names of famous faces they had seen and memorized shortly before. During imagery from LTM, subjects were presented with names of famous faces they had not seen during the experiment. During the imagery + attention conditions, subjects generated images of famous faces from either STM or LTM, and answered questions about some facial features (e.g., "thick lips?"). The order of condition blocks (21 sec each) was counterbalanced across runs. Data were analyzed using multiple regression.

Results: Visual perception of famous faces activated the inferior occipital gyri, lateral fusiform gyri, the STS, and the amygdala. Small subsets of these face-selective regions were activated during imagery. Moreover, visual imagery of famous faces activated a network of regions composed of bilateral calcarine, hippocampus, precuneus, intraparietal sulcus (IPS), and the inferior frontal gyrus (IFG). In all these regions, imagery generated from STM evoked more activation than imagery generated from LTM.

Conclusion: Regardless of memory type, focusing attention on features of the imagined faces (e.g., eyes, lips, or nose) resulted in increased activation in the right IPS and right IFG, regions implicated in many attention, memory, and imagery tasks. Our results suggest differential effects of memory and attention during the generation and maintenance of mental images of faces.

Reference

¹Ishai, A, Ungerleider, LG, Haxby, JV. 2000. Distributed Neural Systems for the Generation of Visual Images. Neuron 28(3): 979-90.

Perceptual Convergence of Objects and Motion

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Introduction. In our visual world, three-dimensional (3D) object shapes can be identified by patterns of motion with no explicit shape information based on contours. The present study used functional magnetic resonance imaging (fMRI) to investigate the human neural system associated with perception and selective attention to 3D shapes defined by rotation-in-depth or static contours.

Methods. Seven right-handed healthy normal subjects participated. Gradient echo EPI images were obtained with a 3T GE scanner. Four types of stimuli were presented, all of which were made of fields of static or moving luminous dots: (I) Shapeless rotation – dots rotating in depth with no apparent shape; (2) Static shapes – 3D objects (sphere or cylinder) defined by stationary dots depicting contours against a background of randomly moving dots; (3) Shape-from-motion (SFM) – transparent, rotating 3D shapes defined by moving dots against a randomly moving background; (4) Random motion control – Randomly moving dots. While maintaining fixation at the center of the screen, subjects responded by pressing buttons in their left and right hands to indicate perceptual judgments of shape (sphere vs. cylinder for the static shape and shape-from-motion stimuli) or rotation direction (clockwise vs. counter-clockwise for the shapeless rotation or shape-from-motion stimuli). For each subject, 110 whole-brain volumes were acquired during each of eight scan series (four for shape discrimination and four for rotation direction discrimination).

Results. Perceptual judgments were highly accurate (over 96 percent for all conditions). Compared to MR responses to the random motion display, shapeless rotation in depth, static 3D shape contours, as well as 3D SFM consistently activated cortical areas in both dorsal and ventral visual pathways. These areas included ventral occipital cortex, the inferior and middle temporal gyri, the superior temporal sulcus, the precuneus, and the intraparietal sulcus. Discrimination of rotation direction in the shapeless rotation stimuli activated motion-related areas (MT+) more than ventral temporal and occipital object-related areas , whereas discrimination of static shapes activated the object-related areas more than MT+. Attending to 3D shape in SFM displays evoked robust activation both in ventral temporal and occipital cortices in the object processing pathway and in motion-related areas (MT+). Attention to rotation in 3D SFM evoked differential activation in motion-related and object-related areas that was similar to that evoked by discrimination of rotation direction in the shapeless rotation stimuli.

Conclusions. Our results indicate that perception of static 3D shape, rotation-in-depth, and 3D shape-from-motion is coded with differential activation of cortical areas in a common neural system. Perception of the shape of objects defined by rotation-in-depth involved additional activation of both motion-related and object-related areas in this neural system.

DT-MRI — Is it going to help us?

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Since the early works of Dejerine, various techniques for studying the 'wiring' of the human brain, (i.e., white matter tracts), have been developed, including Weigert staining, the Klinger technique, active transport of tracer materials, and polarized light methods. However, all of these techniques are necessarily invasive and therefore unsuitable for study of living subjects in a clinical environment.

One technique that shows great promise for the study of white matter tracts in vivo is diffusion tensor magnetic resonance imaging (DT-MRI). In white matter, the diffusivity of a water molecule is much less hindered parallel to the long axis of a group of ordered axons that perpendicular to it. This orientational dependence of the apparent diffusivity is termed diffusion anisotropy.

Many studies have demonstrated significant differences in diffusion anisotropy of white matter between patient and control groups in a wide range of white matter diseases. More intriguingly, several studies have reported significant differences in anisotropy between schizophrenic patients and controls—which some have hypothesized may reflect differences in 'connectivity'

In addition to allowing estimates of diffusion anisotropy, DT-MRI permits the dominant orientation of anisotropic structures within each voxel to be estimated, and therefore allows maps of fibre-orientation to be generated. Within such maps, different tracts can be identified within apparently homogeneously anisotropic tissue on account of their relative orientations.

Extending these ideas further leads to the concept of 'tractography' in which the aim is to reconstruct three-dimensional trajectories of white matter in vivo. When applied to the central portions or 'stems' of major white matter fasciculi, very plausible results can be obtained with current techniques. It is therefore very tempting to speculate that a 'wiring map' of the entire brain could be generated and used to 'explain' differences in 'connectivity' seen in, for example, functional MRI experiments.

This presentation will introduce the concepts of DT-MRI, anisotropy measurements, fibre orientation mapping and tractography and will discuss the concept of inferring 'connectivity' from DT-MRI data.

Neural Substrates of Verb Semantics

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Introduction: We reported previously that accessing knowledge of actions, compared to objects, is associated with increased neural activity in portions of lateral occipitotemporal cortex, and that this increased activity was segregated by material (pictures versus words). Action pictures activated visual motion cortex (MT/MST) and adjacent regions bilaterally, whereas action words (verbs) activated a region in the left middle and superior temporal gyri, slightly anterior and dorsal to MT/MST. However, this segregation by material may have occurred because subjects did not have to specifically consider the motion features of the verbs. In addition, premotor areas may have shown no greater activation for verbs because the verbs used did not stress motoric features. We performed two experiments to test these possibilities.

Methods: We conducted an fMRI study using whole brain echo-planar imaging on a I.5 T scanner. In the first experiment, subjects performed a semantic matching task on triads of nouns and verbs. For verb triads, the critical matching attribute was the kind of motion ("skipping" matches "bouncing" not "rolling") rather than simply the presence of spatial displacement ("digging" matches "shoveling" not "listening" in the original experiment). For noun triads, the critical matching attribute was a particular semantic feature ("owl" matches "eagle" not "robin") rather than simply category membership ("doctor" matches "cop" not "zucchini" in the original experiment). As a baseline task, subjects matched false font strings on the basis of identity. Noun triads, verb triads and baseline trials were presented in I8-second blocks. In a second experiment, subjects performed verb triads in which the critical attribute was the type of body movement ("clenching" matches "squeezing" not "pressing"), while all other conditions were similar. MT/MST was functionally identified in each subject using a localizer scan. Statistical analyses focused on identifying areas of the brain with differences in activation between nouns and verbs within those areas where activity was greater during the semantic tasks (nouns and verbs) compared to baseline.

Results: Motion verb triads, compared to nouns, activated areas in lateral posterior temporal cortex on the left. There was no activity in MT/MST for the semantic task (nouns or verbs) compared to baseline. In the second experiment, triads of body movement verbs activated left premotor areas more than noun triads, in addition to lateral posterior temporal areas.

Conclusions: These results replicate our original finding that accessing knowledge of action verbs, in comparison to concrete nouns, activates areas in the middle and superior temporal gyri. These results also suggest that not only do the neural substrates underlying lexical semantics of verbs differ from those of nouns, but also the neural substrates underlying lexical semantics of motion verbs differ from those of body movement verbs. Our current findings are consistent with the idea that lateral occipitotemporal areas are important for processing semantic features of visual motion, while premotor areas are important for processing semantic features of body movement.

Modulation of the Hemodynamic Response Dynamics in the Hippocampus during a Novel Picture Task

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Introduction: Novel pictures presented in an event-related paradigm have been used to elicit bilateral activation in the hippocampus with an appropriate baseline, ^{1,2} We hypothesize that decreased ability to encode stimuli will result in an increased delay in recognition, and therefore a delay in the hippocampal hemodynamic response. The present study aims to modulate both the magnitude and the onset delay of activation in the hippocampus by altering the spatial coherence of a visual stimulus.

Method: Three male subjects participated in a visual discrimination paradigm. Subjects were required to decide if a picture was an indoor or outdoor scene and as a control task, if a crosshair was gray or white. Four levels of phase scrambling were applied to the pictures (0, 50, 75 and 100 percent). Each run consisted of 108 trials: Ten novel pictures presented for each degree of scrambling, eight pictures (two of each degree of scrambling) repeated five times, and 20 control trials. Each of the stimuli was presented for 2600 ms in a pseudo-randomized order, with an ISI of 1300 ms. Recognition of the pictures was assessed immediately following the scanning session.

FMRI Methods and Analysis: Four sets of 310 echo-planar images using a TR of 1300 ms and eighteen 7.0 mm continuous sagittal slices were collected on a GE 3 Tesla scanner. Sagittal high-resolution MP-RAGE scans were obtained prior to the functional runs for anatomical localization. The functional scans were concatenated, motion corrected, and blurred with a 4 mm rms filter prior to deconvolution of the impulse response functions (IRF). A bilateral hippocampus mask was used to isolate active voxels in the hippocampus from the deconvolved IRF for each degree of scrambling.

Results: Averaged IRF for all subjects and degrees of scrambling showed that a decrease in stimulus coherence resulted in a delay in onset of hippocampus activation, as well as a decrease in magnitude of the activation. Average reaction time increased with degree of scrambling, with the longest reaction time at 75 percent scrambled pictures. Subjects' discrimination performance and recognition was better for the 0 percent unscrambled pictures than for the three levels of scrambling, however performance level was similar for 50, 75 and 100 percent scrambled pictures.

Conclusion: These results show a delay in the activation of the hippocampus with less meaningful stimuli. More meaningful stimuli elicit an earlier, higher magnitude response, presumably due to increased ability to rapidly feature-detect and encode the stimulus. Future use of this paradigm will include finer increments of phase scrambling to determine the precise relationship between the hemodynamic measures and performance. Task-associated delay and magnitude variations in other areas of the brain will also be evaluated.

¹Constable, R.T., et al. (2000) NeuroImage. ²Stark, C.E. and Squire, L.R. (2001) PNAS.

The Influence of the Noise Induced by the fMRI Imager on the Electromagnetic Responses of the Human Brain during a Selective Attention Task

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Introduction: Activation of the auditory system by the scanner noise during fMRI recordings may influence brain-imaging results, particularly when neuronal responses to acoustic stimuli are measured. To clarify this issue, effects of fMRI noise on electro- (EEG) and magnetoencephalographic (MEG) responses were examined during selective attention task. Since brain responses measured at this task depend on the stimulation ratio (Schwent VL et al., 1976, Teder W. et al., 1993, Binder JR, et al. 1994) high and low stimulation ratio was applied at the present investigation.

Methods: Eight healthy volunteers participated in the study. Left- and right-ear tones (about 70 dB SPL) were presented in a random sequence while the subject's task was to detect an infrequently occurring visual target stimulus. The experiment was conducted both in the presence and absence of pre-recorded fMRI scanner noise (about 65 dB SPL to each ear). MEG was recorded with a 122-channel whole-head magnetometer (Neuromag Ltd.) and simultaneous EEG with 64 scalp electrodes. EEG and MEG epochs starting 100 ms before and ending 700 ms after each acoustic stimulus onset were averaged. Data analysis was performed as in our previous studies (Alho K., et al., 1998, Korzyukov O., et al., 1999).

Results: Stimulus presentation against the fMRI noise caused significant prolongation (from 429.85 ms to 453.206 ms) the reaction time to the target. While no significant effect of noise were found for the high rate of auditory stimulus presentation, for the low rate were found significant decrement of the NI amplitude caused by the noise. The electric NI responses and their MEG counterparts (NIm) peaking at about 100 ms from tone onsets had smaller amplitudes and longer latencies in the presence of fMRI noise than in the absence of this disturbance. Equivalent current dipoles (ECDs) for the NIm responses had larger dipole moments in the auditory cortex contralateral to the ear of stimulation. According to these ECDs, the effect of noise was similar in each hemisphere.

Conclusions: The present data indicate that fMRI scanner noise influences stimulus processing in the auditory cortex on the superior temporal plane.

Information-based Multivariate Functional Brain Mapping

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Introduction: Distributed activity patterns are believed to represent complex perceptual, cognitive and motor information at the microscopic scale of individual neurons. A recent study (Haxby et al. 2001. Science. 293(5539). suggests that distributed codes play a major representational role at the macroscopic scale accessible to fMRI as well. If the brain region containing the information is known in advance, the continuous spatial variation of distributed activity can be visualized using univariate (voxel-by-voxel) statistics and tested for significance by conventional multivariate methods. To find informative regions, i.e., to localize not activation, but information inherent in distributed patterns, multivariate measures need to be mapped throughout the volume. Here we present multiscale multivariate methods for I) localization of regions whose spatial activity patterns reflect differences between the experimental conditions and 2) estimation of lower bounds on the information content of those regions.

Method: To localize informative regions, we define a multivariate measure of experimental-condition separation, the local-pattern-difference index, which can rapidly be mapped throughout the volume at different scales. For each voxel in the volume, the map shows how well the signal in the local spherical region differentiates between the experimental conditions. The index can target discriminability of arbitrary subsets of conditions and can be tested for significance for single locations or whole maps by a nonparametric randomization test (Nichols & Holmes 2001. Hum Brain Mapp. 15(1). taking serial autocorrelation and multiple comparisons into account. To obtain a lower bound on the information content of a region, we perform minimum-distance classification of the region's spatial response patterns, predicting the experimental conditions from the data. From the classification matrix, we compute the mutual information between the experimental conditions (input) and the classifications (output). Our methods are efficient enough for whole-volume mapping of the information lower bounds.

The methods have been tested on simulated and real fMRI data and compared to conventional voxel-by-voxel multiple linear regression and, for selected regions, to MANOVA. The simulated data were obtained by embedding a Gaussian random pattern for each condition (a distributed code) in Gaussian noise. Patterns appear and fade according to a realistic hemodynamic response model. The real fMRI data were acquired while subjects passively viewed face and object photos.

Results: Simulation shows that, at a signal-to-noise ratio of 0.I, the local-pattern-difference mapping (II3 local voxels considered together) can still localize informative regions, whereas the linear regression contrast mapping performs at chance level (482 time samples, 96 trials). The information mapping turned out to have an intermediate sensitivity. In the real fMRI data, both local-pattern-difference and information mapping replicated the results of regression analysis and consistently detected additional informative foci.

Conclusion: The mapping of multivariate measures will be crucial to the investigation of distributed representations with fMRI. For detecting regions containing distributed activity patterns that carry information about the experimental condition, multivariate measures are superior to conventional voxel-by-voxel statistics. Mapping of simple multivariate measures combined with nonparametric randomization testing represents a powerful tool for localization. Lower bounds on information content help characterize and compare the information provided by different regions.

Orbital Frontal Aging: Evidence for Early Detection of Cognitive Changes using fMRI

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Introduction: Prefrontal regions are among the brain areas most sensitive to age-related volume loss. However, characterization of whether changes are region-specific or involve the entire prefrontal cortex has received little attention. Based on our observations of orbital frontal cortex (OFC) vulnerability to age-related volume loss, we investigated age differences in OFC function.

Methods: fMRI was performed during delayed match and nonmatch to sample tasks, previously shown to selectively activate medial and lateral OFC, respectively, in young adults. Healthy volunteers (10 men/10 women) were divided into equal-sized cohorts of younger (20-40 years; mean=29.2+6.9) and older (60-80 years; mean=67.I+4.6) adults. Groups did not differ on overall cognitive status (MMSE: Young=29.6 +0.7, Elderly=29.I+I.5), education or depressive symptoms. Brain EPI images were acquired on a Phillips I.5T system (TR=2; TE=40; voxel size=3.75X3.75X3.75) using an event-related design. During the fMRI task, participants chose the stimulus from a pair of stimuli matching a previously viewed target (match to sample) or chose the non-target item (nonmatch to sample) depending upon a trial-specific instruction word.

Results: SPM99 analyses revealed greater activation for medial OFC regions during the match task compared to the nonmatch task and greater lateral OFC activation during the nonmatch task compared to the match task. Once divided by age, younger participants continued to show the medial OFC/match and lateral OFC/nonmatch activation pattern. In contrast, older adults showed less prefrontal activation during the match task and more diffuse prefrontal involvement during the nonmatch task.

Conclusion: This study is the first to assess functional correlates of specific regions of structural loss in OFC in the elderly. Results suggest differential age-related recruitment of prefrontal regions when performing OFC tasks. As OFC regions show early evidence of amyloid deposition in aging and Alzheimer's disease, activation patterns during OFC tasks may mark an avenue of research into predicting cognitive decline.

Functional Magnetic Resonance Imaging during Intentional Deception

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Introduction: The Guilty Knowledge Test (GKT) has been used extensively to model deception. An association between the brain evoked response potentials and lying on the GKT suggests that deception may be associated with changes in other measures of brain activity such as regional blood flow that could be anatomically localized with event-related functional Magnetic Resonance Imaging (fMRI).

Methods: Blood oxygenation level-dependent (BOLD) fMRI contrasts between deceptive and truthful responses were measured with a 4 Tesla scanner in 18 participants performing the GKT and analyzed using statistical parametric mapping.

Results: Increased activity in the anterior cingulate cortex (ACC), superior frontal gyrus (SFG) and the left premotor, motor and anterior parietal cortex was specifically associated with deceptive responses.

Conclusions: The results indicate that: a) cognitive differences between deception and truth have neural correlates detectable by fMRI; b) inhibition of the truthful response may be a basic component of intentional deception and c) ACC and SFG are components of the basic neural circuitry for deception.

Disconnection of Arousal-Limbic-Frontal Networks in Schizophrenia? Integrating fMRI and Skin Conductance Measures

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Introduction: Converging evidence from neuroimaging studies suggests that the limbic, frontal and arousal networks are the core sites of disturbance in schizophrenia. This was the first study to undertake simultaneous fMRI and autonomic arousal (by electrodermal skin conductance responses) recording in schizophrenia.

Method: Subjects included II healthy controls and II early onset schizophrenia patients. To activate the limbic system, threat-related face stimuli were contrasted with neutral face stimuli in the experimental paradigm. fMRI data were acquired using a I.5T scanner: I8 axial slices (6mm thick, .6mm gap), AC-PC orientation, TR 3s, TE 40ms. Skin conductance responses (SCRs) were recorded concurrently using a customized system.

Results: Control subjects showed activation of the amygdala and medial frontal regions with increased phasic arousal (SCRs) when viewing threat-related face stimuli. By contrast, schizophrenia was associated with abnormally large SCRs, but a concomitant lack of amygdala activity: SCRs were associated only with frontal activity. Correlations between a standardised index of fMRI activity in regions of interest and a number of outcome measures (e.g., social functioning, insight) were also explored.

Conclusions: The above findings suggest that schizophrenia is associated with a heightened autonomic sensitivity to threat or the expectation of threat. The apparent lack of amygdala response might reflect the lack of differentiation in amygdala activity between threat and neutral stimuli. Alternatively, schizophrenia subjects may show a functional disconnection in arousal-limbic-frontal networks, such that the heightened autonomic awareness of threat-related stimuli leads to a reliance on frontal executive processing, rather than effective emotion processing in limbic areas.

Activation of Auditory Cortex by Visual Movement in Congenitally Profoundly Deaf People

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Introduction: Recent studies suggest cortical regions functionally specialized for auditory processing may be colonized by signed language (Petitto et al., 2001). We have furthered this finding by showing that such activation is mediated by hearing status: deaf native signers show greater activation of auditory cortices which watching signed language than hearing native signers (MacSweeney et al., submitted). However the extent to which such activation is language specific is unexplored. We address this issue by comparing activation in deaf and hearing native signers of British Sign Language (BSL) while they watched BSL sentences and while they watched 'TicTac' – the gestural communication system employed by bookmakers at race meetings in the UK. TicTac was unknown to all participants and thus formed a control condition comprising non-sense hand and arm movements.

Methods: Deaf (n=9) and hearing (n=9) native signers and hearing non-signers (n=8) were tested. Participants performed 2I second blocks of two experimental tasks interspersed by a baseline task. BSL – Participants watched a video of a native Deaf signer signing 5 sentences. Their task was to make a button press response to a semantically incorrect sentence (I of 5). TicTac- Participants watched the production of 5 'sentence-strings' made up of TicTac gestures. Participants were told to guess the incorrect TicTac sentence and make a button press response. Baseline condition – A small visual cue was digitally superimposed onto the chin of the still signer. Five cues appeared in each block (4 black, I grey). Participants made a button press response to the grey cue. I40 T2* weighted images depicting BOLD contrast were acquired with a slice thickness of 7mm (0.7mm gap) on a I.5T scanner. Fourteen axial slices were acquired in each volume to cover the whole brain (TR=3sec, TE=40ms). An inversion recovery EPI dataset was also acquired to facilitate registration. Non-parametric methods were used to analyse the fMRI data (see Bullmore et al., 2000).

Results: In comparison to hearing signers, deaf signers generated greater activation in posterior superior temporal gyri bilaterally in response to both BSL and TicTac, when contrasted with the baseline task. This region included secondary auditory cortex and surrounding regions. Areas that were recruited to a greater extent in deaf signers by BSL when contrasted with nonsense biological movement were left lateralised and included occipito-temporal junction, extending into inferior parietal lobule, and left inferior frontal gyrus.

Conclusion: These findings add the growing body of evidence indicating cross-modal functional plasticity in classical auditory processing regions when auditory input is lacking from birth. Whether the combination of lack of auditory input and access to a signed language early in life, leading to heightened sensitivity to movement, is responsible for the finding reported here is a matter for further research.

References

MacSweeney, M, et al. Neural systems underlying British Sign Language and audiovisual English processing in native users (submitted). Petitto LA, et al. (2000). Speech-like cerebral activity in profoundly deaf people processing signed languages: Implications for the neural basis of human language. *Proc Natl Acad Sci USA* 97 (25): I396I-6.

Right Parietal Operculum and the Sense of Self

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Introduction: Evidence suggests a shared representation of action in motor regions whether one performs or merely observes an action. This requires some means of representing the sense of ownership of an action when imitating the actions of someone else. The right parietal operculum has been suggested as a candidate region for maintaining this sense of self. We directly tested this hypothesis in a group of subjects who imitated or observed their own or others' hand actions. We predicted that the right posterior superior parietal cortex would be active when the subjects' hand/arm positions matched what they saw (either during imitation or observation) as suggested in monkey literature, whereas the right parietal operculum would be active specifically when the subjects imitated their own hand movements matching their hand/arm position. The assumption was that the closer the visual features of the stimuli (agent to be imitated) to the expected visual input from observing one's own hands, the stronger the sense of self needed to preserve the distinction between their own actions and the actions observed on the screen.

Methods: Eighteen healthy subjects were studied with a 3T MRI scanner with EPI upgrade. Functional EPI scans (gradient-echo, TR=4000ms, TE=25ms, I28x64, 26 slices, 4mm-thick, Imm-skip) were acquired covering the whole brain. Image processing and statistics were performed as in [I]. Subjects imitated or observed (Task: Imt vs. Obs) previously recorded hand-movements performed by themselves or by someone else (Agency: Self vs. Other). The actions were movements of the index fingers of both hands, in which the hand/arm positions were either matching the subjects or facing toward them (Orientation: Away vs. Toward).

Results: I.) Collapsing across Tasks, a main effect of Orientation (Away>Toward; p < 0.05) was observed in the superior parietal cortex (right>left). The simple main effect of Agency (Self-Away>Other-Away) indicated that activity in this region was greatest when visual stimuli were matched for both agent and hand/arm orientation. 2.) During Imt, greatest activity in the right parietal operculum was seen for Self-Away compared with the other three Imt conditions.

Conclusion: These observations are consistent with the concept of the right posterior superior parietal cortex as important for integrating visual (orientation, body part features) and somatosensory (proprioception, position) signals. Moreover, this study provides direct evidence supporting our hypothesis that the right parietal operculum becomes more active as the agent to be imitated becomes more visually similar to oneself and greater effort is necessary to distinguish between the action being performed by the self and the action being imitated.

References

¹Iacoboni M, et al. (1999) *Science* 286:2526-8. ²Graziano SA, et al. (2000) *Nature* 290:1782-6.

An fMRI Study of Automatic Beliefs about Gender and Race

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Introduction: We used functional magnetic resonance imaging (fMRI) to determine areas of brain activation underlying automatic, stereotyped associations about gender and race. We hypothesized that ventromedial prefrontal cortex would show increased neural activity when subjects made automatic cognitive associations about gender and race. In addition, we predicted that amygala activation would be present when subjects were asked to associate various attributes with race.

Methods: Sixteen right-handed Caucasian-American normal volunteers (eight males, eight females) participated in the study. A modified version of the Implicit Association Task (IAT; Greenwald et al., 1998) was used to indirectly measure gender and racial stereotyped beliefs. In this task, subjects classify names and attributes by pressing a response key under two conditions; one in which congruent stimuli share the same response key, and the other in which incongruent stimuli share the same response key. A third condition was added as a baseline cognitive task. Functional MR images were obtained at 3 Tesla while subjects performed the task. Subjects also completed explicit questionnaires a ssessing gender and racial beliefs following the scanning session. All functional MRI data was processed using SPM99 (Wellcome Department of Cognitive Neurology, UK) using standard realignment, normalization, and smoothing procedures. A random effects analysis will be conducted. Performance and questionnaire data will also be correlated with functional imaging data.

Results: In progress.

Conclusions: This study will demonstrate the functional neuroanatomical substrates of automatic, stereotyped beliefs about race and gender. In addition, it is expected to provide further evidence of the role of ventromedial prefrontal cortex in mediating social cognition and behaviour.

'Imaging A Socially Unacceptable Image'—Voxel-based Morphometry in Tardive Dyskinesia and Schizophrenia

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Introduction: Tardive Dyskinesia (TD) is an anti-psychotic induced chronic movement disorder causing significant disfigurement and distress. In TD, there is contradictory evidence for neuropathology in the neo-striatum. Neuro-imaging studies so far have focused only on specific cerebral structures. Voxel Based Morphometry (VBM) now provides an opportunity to look at the structural abnormality in the brain as a whole.

We hypothesized that the patients with schizophrenia would have greater brain morphological abnormalities compared to healthy volunteers and such abnormalities in patients with associated TD would be even greater.

In this study, we aimed first to establish whether morphological brain abnormalities are present in people who develop schizophrenia and TD that are different, either in extent or location, to those with schizophrenia alone and healthy volunteers. Our second aim was to establish if such abnormalities correlate with clinical parameters.

Methods: To test our hypothesis we designed this cross-sectional cohort study with two matched control groups. Fifteen men with schizophrenia plus orofacial TD and thirteen patient controls with schizophrenia alone were recruited from three teaching hospitals in west London. Patients with akathisia and parkinsonism were excluded. TD was rated using Abnormal Involuntary Movement Scale (AIMS). Twelve healthy volunteers were recruited from West London. Both the control groups were matched for age and gender. Patient control group was also matched for anti-psychotic medications.

High-resolution structural TI scans were used for Standard VBM (Ashburner et al., 2000) analysis using SPM99. We created our own template image, for normalization, which was specific to our scanner and TI protocol. The normalized images were then segmented and smoothed. Smoothed gray matter images were used for the statistical analysis. One-way ANOVA was used for comparing the structural changes in the three groups and ANCOVA was used to relate it to the clinical parameters.

Results: The three groups were comparable for mean age (F=0.9, p=0.6). None of the participants met ICD ten criteria for alcohol/substance dependence. The length of illness (t=-I, p=0.3), the duration of anti-psychotic treatment (t=-I.2, p=0.2) and the class of anti-psychotics received (X2=2.8, p=0.4) were comparable in the two patient groups. All the patients in TD group and only half of the schizophrenia group have received other medications (X2=9.6, p=0.05).

In both the patient groups, there is bilateral significant reduction in gray volume in the temporal poles and inferior surface of cerebellum. The superior and middle temporal gyri, frontal and occipital poles show volume reductions only on the left side. These volume reductions were significantly more extensive in patients with TD compared to the healthy volunteers.

The pattern of volume reductions remained the same even when the age was used as a covariate. Only in the TD group, AIMS score significantly co-varied with volume reductions in temporal poles bilaterally,

Conclusions: Our patients with schizophrenia and TD have significantly greater gray matter structural abnormalities associated with schizophrenia. Gray matter volume reduction is not confounded by the age and the TD ratings co-vary with specific regional gray matter changes in the brain.

fMRI Encoding and Retrieval in Normal Aging and MCI

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Introduction: Mild cognitive impairment (MCI) patients exhibit greater than normal memory loss for their age, but do not meet the criteria for Alzheimer's dementia (AD). A proportion progress to AD at follow-up while the remaining subset does not. Our study used non-verbal encoding and retrieval during fMRI in MCI and agematched controls (NC).

Methods: Ten NC and eight MCI (mean age–73.3 and 69.1) underwent fMRI (single shot spiral imaging; TR/TE-3000/40 ms; 30 to 34 coronal 5mm thick slices). Volunteers decided whether pictures were natural vs. man-made (deep) and a color vs. black and white (shallow) during incidental encoding. After a delay, they performed recognition tasks (deep and shallow) deciding which photograph was old vs. new. All tasks were contrasted to baseline fixation.

Results: Behavioral: MCI performed significantly less accurately than NC on shallow encoding and deep retrieval and significantly more slowly on deep encoding and both retrieval tasks (ANOVA). NC performed significantly better during deep vs. shallow retrieval. fMRI: AFNI was used to analyze fMRI data. An ANOVA was performed to compare differences between memory tasks in MCI and NC groups. NC showed greater activity in the occipitotemporal and cerebellar areas during deep relative to shallow encoding (p < 0.05) In addition to these regions the MCI activated the left inferior frontal region (BA 45) in both tasks. NC activated the prefrontal and anterior medial temporal regions. Specifically activity was noted in the right entorhinal cortex and inferior frontal regions during deep retrieval and in the parahippocampal gyrus/amygdala and dorsolateral prefrontal regions (DLPFC) during shallow retrieval. The MCI had greater prefrontal activation than the NC during both retrieval tasks. Unlike NC, MCI did not activate the anterior medial temporal region during retrieval.

Conclusions: Both encoding task activated a similar network of regions in NC and MCI. MCI may have recruited left BA 45 more than NC, as they required more semantic elaboration to perform both encoding tasks. Unlike NC, MCI did not benefit from the levels of processing manipulation. Differences in prefrontal activity in NC may reflect differences in attention or task difficulty as demonstrated by superior performance on the deep retrieval task. Prefrontal hyperactivation in MCI during retrieval may reflect increased attention or effort in attempting to perform the task. A continuum in activation may exist whereby hyperactivation may reflect compensatory mechanisms and be a precursor to hypoactivation. The failure of MCI to activate the anterior medial temporal regions during retrieval may correlate with poorer performance.

Objects, Concepts and the Brain

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Previous functional brain imaging studies from our laboratory and others indicate that different object categories such as animals and tools are associated with different patterns of activity in ventral temporal (fusiform gyrus), lateral temporal (middle temporal gyrus and STS) and premotor cortices. We have suggested that these activations reflect experience-dependent tuning of neurons in these regions to category-related differences in object form (ventral temporal), object-associated motion (lateral temporal), and object manipulability (premotor). This presentation will highlight findings from recent fMRI studies that extend these findings to learning about novel stimuli, and to abstract knowledge about social and mechanical concepts.

In one study, subjects were given extensive experience performing tasks with a set of novel, tool-like objects. Comparison of scans before and after training revealed the emergence of activity in the same regions active when subjects name pictures of well-known tools. Specifically, experienced-induced changes were found in the fusiform gyrus, left middle temporal gyrus, and left ventral premotor cortex. Thus, manipulating and performing tasks with novel objects lead to the emergence of the same pattern of neural activity seen when well-known tools are viewed and named. In another study, subjects viewed and interpreted animations composed of simple geometric forms. The animations were designed to depicted either a social situation (e.g., children sharing ice cream) or a mechanical apparatus (e.g., pin ball machine). Viewing the mechanical cartoons elicited activity in regions associated with tool naming (medial aspect of the fusiform gyrus, left middle temporal gyrus). In contrast, viewing the social vignettes elicited activity in regions associated with naming pictures of animals and viewing human faces (lateral fusiform, STS), as well as other regions associated with social cognition (right amygdala and ventromedial prefrontal cortex). These results suggest that object concepts are represented in the brain by distributed feature-networks. These networks may provide the foundation for more abstract, object-associated knowledge.

Interleaved Echo-Volume Imaging

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Introduction: The advantages of three-dimensional (3D) volume acquisition as compared to two-dimensional (2D) multi-slice imaging include the feasibility of thinner slices that are contiguous and reduced inflow of unsaturated spins near the middle of the imaging volume. Reduction in slice thickness can be particularly important for high resolution fMRI where the goal is to obtain images with minimal partial volume effects. In addition, spin dephasing due to intravoxel gradients which result in signal loss can be reduced with increased inplane resolution. The acquisition presented here is a multi-shot half k-space echo-volume imaging strategy with interleaving along ky. Preliminary results at I.5 T using I.5 mm cubic voxels in a bilateral finger-tapping task demonstrate that the acquisition is well suited for high-resolution fMRI.

Methods: A selective RF excitation is used to excite a 3D slab, followed by acquisition of partial k-space data with inter-leaving along the phase-encoding direction. Using a multi-shot strategy, the slice-encoding gradient is incremented for each repetition of the RF pulse, hence reducing the sensitivity of the sequence to static field inhomogeneity in the z-direction.

All studies were carried out on a $1.5\,\mathrm{T}$ GE Signa scanner using a local gradient coil/RF coil insert. $1.5\,\mathrm{mm}$ cubic voxels were acquired using a $128\,\mathrm{x}$ $128\,\mathrm{x}$ 16 image matrix, and $19.2\,\mathrm{x}$ $19.2\,\mathrm{x}$ $2.4\,\mathrm{cm}$ FOV. TE/TR were set to $40/150\,\mathrm{ms}$. The flip angle was slightly reduced to 70 degrees to decrease signal saturation.

EPI imaging is inherently sensitive to field inhomogeneities and off-resonance effects in the phase-encoding direction which result in geometric distortion and ghosting artifacts in the reconstructed image. Inaccurate timing between even and odd echos or between interleaved echos can also lead to ghosting artifacts. To reduce ghosting artifacts from fluctuations between interleaved excitations, a navigator echo is acquired before application of the phase-encoding gradients. In addition, the phase correction technique discussed by Jesmanowicz et al. (*ISMRM*, p. 1239, 1993) was used to correct for timing errors between even and odd echos from each RF excitation.

Results: Implementation of the navigator echo along with the phase correction technique resulted in substantial reduction in ghost artifacts and distortion in the phase-encoding direction. The improvement in point spread function due to interleaving becomes evident when images from the lower brain region is compared using the 3D interleaved echo-volume imaging technique with a single-shot EPI acquisition. Overall, the 3D acquisition strategy has shown to be a viable method for high resolution 3D fMRI studies.

Conclusions: The acquisition of high resolution 3D volume data sets with reduced slice thickness can improve the slice profile, reduce partial volume effects, and reduce signal dephasing. The combination of interleaving and half k-space acquisition along the phase-encoding direction narrows the point spread function in this direction. The technique presented here could be beneficial for high-resolution fMRI studies or for imaging regions of the brain, such as the lower brain region, where susceptibility artifacts limit image quality.

Neural Correlates of Inner Speech, Auditory Imagery and Auditory Hallucinations

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Over the last decade, functional neuroimaging has been used to examine the pathophysiology of auditory hallucinations in two main ways. One has been to examine the neural correlates of cognitive processes putatively relevant to auditory hallucinations. This entails the comparison of patients (e.g., with schizophrenia) who have a history of frequent hallucinations, patients with no history of hallucinations and healthy volunteers. This approach has been complemented by studies which have measured regional activity within the same individual when they were and were not experiencing auditory hallucinations. Much of the research in this area has been driven by a psychological model that proposes that hallucinations represent inner speech which has been misidentified as 'alien' due to defective verbal self-monitoring. Overall, the neuroimaging data are consistent with this model, but the data also indicate that this is not the sole factor underlying auditory hallucinations in schizophrenia. Findings from research on hallucinations have also contributed to our understanding of normal inner speech and auditory verbal imagery, and informed the development of new psychological and biological treatments for hallucinations.

Modulation of Visually Evoked Activation by Eye Movements in Human Extrastriate Cortex

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Introduction: Our stable perception of space is maintained in spite of the extreme instability of the retinal image caused by gaze shifts. In monkeys, single units in the lateral intraparietal sulcus, frontal eye field, and extrastriate cortex update the representation of space in association with eye movements: neurons in these areas become activated when an eye movement brings the receptive field onto a previously stimulated screen location. In humans, we have previously reported a similar pattern of activation in posterior parietal cortex. Voxels in the posterior intraparietal sulcus respond weakly to visual stimuli presented in the ipsilateral visual field. This fMRI activation is greatly enhanced when an eye movement brings the stimulus location into the contralateral visual field, even though the stimulus is no longer physically present. We have now investigated spatial updating at earlier stages of the visual hierarchy.

Methods: We used retinotopic mapping techniques to identify the borders of visual areas in striate and extrastriate cortex. We then scanned subjects during three types of trials: (I) In stimulus-only trials, a highly salient stimulus flickered in the periphery while subjects maintained fixation. (2) In saccade-only trials, subjects made saccades to stable targets when prompted by an auditory cue. (3) In spatial-updating trials, the stimulus appeared briefly and subjects made a saccade only after its offset.

Results: In stimulus only trials, we found lateralized sites of activation in multiple visual areas. In saccade only trials, we found bilateral activation in the frontal and supplementary eye fields. Both sets of areas were activated in the spatial updating trials. We also found an additional site of activation deep within the caudal portion of the intraparietal sulcus, anterior to V3a. Prior to the eye movement, the visual stimulus activated this region in the contralateral hemisphere. This activation then shifted to the opposite hemisphere with the eye movement, even though the stimulus had already been extinguished.

Conclusions: The activation pattern observed in spatial updating trials is consistent with earlier electrophysiological studies in monkeys describing the dynamic updating of memory traces during eye movements. These data establish that spatial updating is observable in humans using event-related fMRI. These results also lend support to the idea that the human homologue of the monkey LIP is located in the intraparietal sulcus (Sereno et al., 2000).

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Functional Brain Activation during Navigation through Novel versus Familiar Virtual Environments

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Introduction: Studies in both human and non-human species demonstrate that the hippocampal region and parietal cortex play an important role in navigation through space. The recent development of virtual environment technology allows for the study of human navigation in the neuroimaging environment. The purpose of this study was to examine functional brain activation during virtual environment navigation and to contrast the brain regions involved in the learning of a novel environment versus navigation through a familiar environment. It was hypothesized that navigation would activate structures in the parietal cortex, posterior cingulate gyrus and medial temporal lobes. In addition, because previous studies have demonstrated that the medial temporal lobes play a greater role in the learning of new information than in the recall of old information, we hypothesized that the learning of a novel environment would result in increased activity in the parahippocampal region.

Method: Whole brain EPI images of adult subjects were acquired on a Phillips I.5 Tesla MRI system (TR= 3000ms; TE=39ms; voxel size=3.75 X 3.75 X 5.5) using a block design of I0 alternating 60 second epochs of navigation and a control condition. Movement through the virtual environment was controlled with a joystick. Subjects were scanned under 2 task conditions. In the first task (novel condition), subjects were required to learn the spatial locations of several objects in a novel environment. In the second task (familiar condition), subjects were required to navigate between object locations in a familiar environment. The control condition for both tasks involved passively traversing through a virtual environment without having to learn or remember spatial locations.

Results: Compared to the control condition, several brain structures were activated in both the "novel" and "familiar" navigation tasks. These structures included the medial parietal lobe (precuneus and cuneus), bilateral superior parietal lobule, posterior cingulate gyrus and cerebellum. Consistent with our predictions, the initial acquisition of a novel environment required greater activation bilaterally in the posterior parahippocampal gyrus. Navigation through a familiar environment resulted in increased activity in the anterior cingulate gyrus and prefrontal cortex.

Conclusions: These results extend previous findings in both human and non-human species and demonstrate that a network of structures involving the parahippocampal gyrus and parietal cortex subserve human spatial navigation. The initial learning of a novel environment requires medial temporal networks which are not recruited to the same extent during navigation through familiar surroundings.

Unpleasant Pictures Induce Coupling between Amygdala and Visual Areas

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Introduction: Several functional imaging studies have shown that unpleasant visual stimuli evoke more activity in visual cortex than neutral ones (Lane et al., Neuropsychologia 37: 989-97, 1999; Taylor et al., Neuropsychologia 38: 1415-14225, 2000). Our previous results showed that unpleasant and interesting (high arousal with neutral valence) pictures elicit greater visual cortex activity when compared to neutral pictures. In the present study we investigated the hypothesis that amygdala activity could be involved in the modulatory effects of the visual cortex by unpleasant stimuli but not for interesting ones. For this we studied the "functional connectivity" between the amygdala and visual areas to test whether these regions are differentially coupled for unpleasant stimuli when compared to interesting stimuli.

Methods: We employed fMRI in six subjects. Stimuli included four categories of pictures mostly taken from the International Affective Pictures System: unpleasant, pleasant, neutral and interesting (high arousal with neutral valence). There were eight blocks for each category, each one consisting of a 15 s stimulus presentation followed by a 15 s of fixation. We investigated the functional connectivity of the amygdala as a function of stimulus category. The signal in the amygdala and the interactions of this signal and the experimental conditions were used as predictors in a multiple regression analysis to determine which voxels in the brain are differentially correlated with the activation in the amygdala as a function of stimulus condition.

Results: Visual areas showed increased coupling with the amygdala during unpleasant compared to neutral stimuli. The fusiform and orbital gyri showed increased coupling with the amygdala during unpleasant compared to interesting stimuli. No brain regions exhibited increased of coupling with the amygdala during interesting compared to neutral stimuli.

Conclusion: Our results suggest that the functional connectivity or coupling between the amygdala and visual areas is stronger during unpleasant stimuli. Anatomical data in non-human primates show projections from the amygdala to all levels of visual processing. Thus, although the present analysis does not allow us to determine the direction of the interaction, we suggest that the amygdala has a modulatory effect on visual cortical activity. Finally, we did not find increased coupling between the amygdala and visual areas in response to arousing stimuli of neutral valence, suggesting that the emotional relevance of the stimulus may be a critical factor for the coupling between the amygdala and visual cortex.

The Cortical Network Associated with Predictable and Unpredictable Visual Stimuli Revealed with fMRI

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Introduction: Movements are often directed by visual information. The ability to predict visual information is an important determinant of the nature of the underlying visuomotor control. In the present study, we alter the predictability of the visual stimulus, and investigate task-related changes in a cortical visuomotor network. FMRI was used to reveal the influences of stimulus predictability on a cortical network that underpins visually guided motor behavior. It was hypothesized that activation in sensory and sensory association loci would be enhanced when visual information guiding motor behavior could not be predicted, thus relying heavily on moment to moment changes in visual input.

Methods: Six subjects participated in the present study. The visual stimulus was a vertical bar that served as the target and moved horizontally across the screen, changing its direction in one of two ways; I) in a sinusoidal manner, predictable pattern or 2) randomly (unpredictable). These two conditions were run in separate scans. Subjects tracked variations in stimulus location by altering force exerted on a transducer held in the right hand. Tracking behavior was assessed via phase lag (delay between input and motor response) and performance accuracy (root mean square). Subjects were informed of the task condition prior to the scan. Visual input from both conditions were matched for the number of stimulus transitions (directional change) and only varied in their predictability. Scans were conducted using a blocked 'on-off' design (20 sec of tracking followed by 20 sec of rest). Activation maps were acquired with a 1.5 T scanner (Signa, GE Medical Systems) using the boxcar correlation (field of view FOV20cm, TE/TR/Ë=40/1500/70) including image coregistration in three spatial dimensions to reduce the effects of small head motion. Two analysis approaches were used. First, a voxel-by voxel paired t-test examined task related differences with significance set at p <0.05. Second, regions of interest were defined anatomically for individual subjects in six loci identified as components of the visuomotor network. Averaged signals in the ROI were then compared using a paired t-test with significance set at p <0.05.

Results: Results revealed a network of activated cortical and subcortical areas that include the primary motor and posterior parietal cortex (BA 5) and inferior parietal lobule contralateral to hand movements, bilateral supplementary motor area and eye fields, dorsal and ventral premotor and cerebellar cortex. Behavioral data revealed a shorter phase lag between visual input and motor responses and improved performance during predictable versus unpredictable tracking. Several loci within the network were modulated by the predictability of the visual stimulus and most were enhanced during the unpredictable versus predictable tracking task.

Conclusions: The present study reveals a consistent visuomotor network of which some components are modulated by the predictability of a visual stimulus that guides behavior. Primary visual cortex does not appear to be sensitive visual stimulus predictability, while association, transformation and motor-related loci are modulated. This study has provided evidence of the modifiability of neural substrates associated with sensory guided hand movements.

Modulation of Cortical Activity Driven by Changes in Sensory Afference and Sensorimotor Transformations Measured via fMRI

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Introduction: While the primary somatosensory cortex (SI) the first cortical recipient of ascending input there it is also influenced by centrally originating input. This highlights the potentially important role for SI related to task-specific control of primary afferent inflow during the execution of sensorimotor behavior. The effects of these converging peripheral and central inputs on SI can be investigated by measuring responses to varied characteristics of sensory inputs and different central states. The latter is achieved by manipulating attentive states, or the anticipation of sensory events. Using fMRI the present studies investigated the effects of peripheral and central events on the sensory evoked responses in human primary somatosensory cortex. Responses in SI were measured when: I) the specific characteristics of the mechanoreceptor discharge is altered (varied peripheral input), 2) when the peripheral afference is was varied along with the task relevance (varied peripheral and central inputs), and 3) when the task-relevant sensory afference is altered in its predictability (varied central input).

Methods: Sixteen subjects participated in these experiments. FMRI was conducted using a scanner operating at I.5 T and vibration was delivered to the volar surface of the right index finger with a custom-built magnetomechanical device. Images were analyzed using Analysis of Functional Neuroimages (AFNI) software with boxcar correlation. All tasks were conducted in a blocked design (I5 or 20 sec of 'on' with identical 'off'). Vibrotactile stimuli were delivered I) in a single run using three different waveforms that targeted different mechanoreceptor populations at three different amplitudes (passive vibration-content specific), 2) at three different amplitudes in separate runs with and without the addition of a task that used such input to guide motor behavior 3) at one amplitude that varied in its predictably and was used to guide motor responses. In 2 & 3 motor responses made by the left hand were simultaneously guided by vibration amplitude delivered to the right.

Results: Results showed that primary somatosensory cortex (SI) reliably reflects changes in vibration amplitude applied to the finger during passive vibration and also in the presence of a task that modulates the activity in SI. The relationship during passive vibration appears to be sensitive to the content of the mechanoreceptive input. Responses in SI were enhanced when sensory input was relevant to the task compared to passive application. Furthermore, these responses were not altered when the tasks compared both contained relevant somatosensory input and only the predictability of such input was altered.

Conclusions: We conclude that responses in SI are determined by the amplitude of peripheral input and also by task-relevance. In addition to supporting a linear stimulus-response relationship, activity in SI is selectively modulated under specific task conditions. First, compared to passive stimulation, responses are enhanced when the somatosensory stimulus is relevant to motor behavior. Second, when comparing two tasks where the stimulus is always relevant, SI responses do not alter. These results have important implications for study of short-term changes in cortical representation and ascending somatosensory pathways.

Specificity and Plasticity in Human Brain Development

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I will review ERP and fMRI results of visual and language processing in normal adults and in those who have had different sensory and/or language experience. Taken together these studies suggest that within vision and audition and language different neural systems display considerable variability in the degree to which they are modified by early experience. Within vision, early auditory deprivation has most marked effects on the organization of systems important in processing motion information. Within the visual and auditory systems sensory deprivation has more effects on the representation of the peripheral than of the central fields. In addition, different subsystems within language display varying degrees of modifiability by experience. The acquisition of lexical semantics appears relatively robust and invariant even in individuals with markedly different timing and modality of language input. By contrast, systems active during grammatical and phonological processing display marked effects of alterations in the timing and nature of early language input. These results converge with other lines of evidence that suggest it is important to distinguish these different aspects of language, and they raise hypotheses about the initial development of these different language systems.

Parallel studies of normal infants, children, and adults and studies of those with abnormal development provide further evidence for the roles of genetic factors and experience in human neurobehavioral development. The results of these several different types of experiments provide evidence that some systems within the human brain retain the ability to change, adapt, and learn throughout life, while other aspects of human neural and behavioral development display multiple, specific and different critical periods.

Reduced Sensorimotor Cortical Basal Activity in a Rat Model of Parkinson's Disease as Measured by fMRI

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Introduction: For studying the complex Basal ganglia (BG)-cortex circuit we use the well-established Parkinson's disease (PD) rat model. We previously showed that following stimulation the BOLD signal is increased in the right and the left sensorimotor cortex in the PD model rats compared to sham-operated rats (Pelled et al., 2002). Since BOLD fMRI measures the relative changes in the oxy/deoxy-hemoglobin ratio, either a cortical over-activation or a reduction in the basal neuronal activity level might explain these findings. Therefore, we measured the temporal, and spatial characteristics as well as the normalized mean of the BOLD signal fluctuations in rest condition, in the PD model rats and compared to sham-operated rats.

Method: Ten male Sprauge-Dawley rats were anesthetized stereotaxically and injected into the right substantia nigra with the selective neurotoxin 6-hydroxydopamine. A group of ten additional rats went under the same surgical procedure, but were injected with saline (sham-operated). For fMRI measurements rats were anesthetized with urethane and were restrained in a home-built head and body holder. After MRI measurements, tyrosine hydroxylase histology was preformed on the PD model rats. A pronounced dopamine cell loss was found in all the PD model rats. MRI measurements were performed on a 4.7 T BioSpec system (Bruker, Germany) using a 22-mm Bruker head dedicated volume coil. For functional studies, a gradient echo-EPI sequence was applied on coronal and transverse slices. ROIs in the right/left sensory and motor cortex, and for control the right/left visual cortex, the right/left globus pallidus, caudate-putamen, and the ventro-lateral nuclei of the thalamus were chosen, and normalized mean, spatial and temporal standard deviation (SD) of BOLD signal fluctuations were calculated. Two-tailed t-tests between the groups were performed.

Results: The mean BOLD intensity is a complex function of anatomy and activity, while the BOLD temporal fluctuations represent the spontaneous activity and spatial fluctuations represent the level of the homogeneity inside the measured area. Significant bilateral reduction of the mean intensity and the temporal and the spatial fluctuation, was found in the sensorimotor cortex in the PD model rats. In the BG areas, a significant increase in all the above parameters was found in the PD models rats compared to sham-operated rats. Based on electrophysiological studies, a model describing the BG-cortex connections was established. However, the results of several autoradiography studies that were preformed using the unilateral rat model and the monkey model for PD, do not completely agree with the above model. The results demonstrated in our study, are consistent with the autoradiography findings regarding the BG-cortex connections.

Conclusion: Our results suggest that the fMRI over-activation of the sensorimotor cortex that was found might correspond to the decreased basal activity level and not neuronal over-activation, this would concur with the classical BG-cortex circuit model. This basal activity level method could be easily applied in studying other neurodegenerative and psychiatric diseases in animal models and humans.

Reference

G Pelled, H Bergman & G Goelman. (in press, 2002) Bilateral over-activation of the sensorimotor cortex in the unilateral rodent model of Parkinson's disease – a functional magnetic resonance imaging study. European Journal of Neuroscience.

Externalizing Cognitive Processes — A Methodological Research Tool

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Introduction: We present a new research tool that "quantifies" the learning process, and enables "visualization" of the inner cognitive paths. It presents the cognitive processes of an individual as a collection of continuous graphs. It also provides analysis of an individual's cognitive profile and offers new kinds of insights into the cognitive process; it is unique in the kind of conclusions it suggests and in the wide scope of conclusions it allows one to make. We describe this tool vis-à-vis a case in which it was used for a pilot study of the cognitive abstraction processes that are involved in learning a piece of abstract mathematics. We argue that this tool combined with fMRI techniques could make a very powerful research tool, which will relate the cognitive conceptual processes to the neurological processes.

Methods: We used a computerized module to monitor separately the conception progression of ten mathematical aspects of the concept to be learned and three general aspects of the learning in each of the participants. We observed two processes that we had identified theoretically: a bottom-up Abstraction—CAP and a top-down Reversed-Abstraction—RCAP. Thus the participants learned a completely new, highly abstract concept; difficult to learn in order to initiate these Abstraction processes. Also since we aimed towards a maximal exposure of the participants' thoughts we had used massive reasoning, construction of examples and Identification assignments. Additionally at completion of each of the sections (=level of abstraction) the learners had to describe their feelings and define the concept verbally. Thirty-nine different indexes were designed to evaluate separately positive, negative and total progression of the conception of each of the different aspects of the concept at each point (point = assignment, 204 points in total in about 3 hours). The progression of the indexes' values was graphed on three axes: The Process Progression Axis The Location (in the module) Axis and The Time Axis. Subsequently, the analysis was done on both, the group level (based on the average graphs of the two groups of learners), as well as on the individual level (based on the individual profiles).

Results: To mention few of the dozens of conclusions that we managed to derive in our pilot research:

- I. The conception processes are more efficient via CAP than via RCAP.
- 2. The CAP enables the construction of a more stable schema than the RCAP does.
- 3. The RCAP is more influential than the CAP.
- 4. The RCAP directs the construction of the conception schema towards the positive direction more than the CAP does.
- 5. The RCAP enables the construction of a more flexible schema than the CAP does.

Conclusion: Our goal was to design a device for documentating the learning processes: a kind of a "cognitive camera." Utilizing more advanced settings that simultaneously employs many different devices (multi-media, electronic beam technology, etc.) would enable one to monitor any kind of path, not only linear. In particular incorporating fMRI techniques carry a promising potential for a deeper understanding of the complex learning processes.

Neural Correlates of Visual Working Memory: BOLD Predicts Task Performance

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Introduction: We hypothesized that distinct components of a working memory task, namely encoding, maintenance, and retrieval, would engage different brain regions to a greater extent on correct trials compared to incorrect trials and provide the neural correlates of WM performance.

Methods: Nine subjects participated in an event-related fMRI study on a 3T GE Signa. Each trial consisted of a sample stimulus, a delay, and a test stimulus, followed by a response period. We compared activations for correct vs. incorrect trials.

Results: Regions exhibiting increased encoding (activity evoked by the sample stimulus) for correct trials involved occipital (including VI and dorsal extrastriate), and parietal areas, with the largest contribution in dorsal extrastriate cortex. Regions exhibiting increased maintenance (activity during delay) included parietal (including the intraparietal sulcus) and dorsolateral prefrontal areas, with the largest contribution in the parietal cortex. Regions exhibiting increased retrieval (activity evoked by the test stimulus) included occipital, parietal, dorsolateral and ventrolateral prefrontal, and cingulate areas, with the largest contributions from cingulate and ventrolateral prefrontal. Also, correct trials involving a change (mismatch trials) compared to those without a change (match trials) more strongly engaged the parietal and prefrontal areas.

Conclusions: Our results demonstrate that successful performance of WM depends on the differential modulation of distinct occipital, parietal, and prefrontal regions during specific task components. Finally, BOLD also predicts the pattern of activation due to distinct types of correct and incorrect trials, such as the increased activation in early visual areas associated with reporting a change when none occurs in the display.

What is the Optimum Spatial Resolution for fMRI?

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Introduction: In functional MRI (fMRI), it is desirable to go to higher field strengths or use surface coils due to higher S/N and functional C/N. However above a given image S/N, temporal S/N will plateau. A beneficial strategy is to image at the spatial resolution where temporal S/N reaches this "plateau." In that manner gains achieved by higher field strengths or surface coils can be capitalized on. The work presented here characterizes the relationship between temporal and image S/N for a range of spatial resolutions at 3T on humans and phantoms. A relationship between physiological and intrinsic noise that optimizes temporal sensitivity is presented.

Methods: MR data were acquired on a 3T GE scanner using a quadrature head coil (Medical Advances). A single-shot EPI was used for single slice imaging (TE:30ms, TR:1s, 4mm, 128x85 reconstructed to 128x128). The spatial resolution was modulated via FOV stepping: 14cm, 16cm, 18cm, 20cm, 22cm, 24cm, 36cm, 48cm, 60cm. For each FOV step 140 images were obtained. The bandwidth was fixed at 100kHz. Intrinsic (thermal) noise measurements were acquired for each FOV by setting the flip angle to 00 and calculating the voxel-wise temporal standard deviation (0). Two phantom and two subject data sets were acquired under an approved IRB protocol. Each data set was organized according to FOV and processed separately. The average temporal amplitude (Sav) and the temporal standard deviation (t), of the signal were calculated for each voxel. The temporal S/N (Sav/t) and image S/N (Sav/0) were calculated and then averaged over the entire brain; a central ROI was used for the phantom data.

Results: For the phantom data there a linear increase in the temporal S/N with increases in image S/N, as expected. The subject data show that the temporal S/N reaches a plateau with further increases in image S/N. The resolution at which the plateau in temporal S/N begins depends on the intrinsic S/N, which is determined, among other things, by the RF coil, field strength, and the size of the activated unit.

Analysis of the observed noise (t/0) suggests that the plateau is approached when temporal noise approximates 2x the intrinsic noise. Intrinsic noise values were found to be constant for the resolution range, as expected due to the fixed bandwidth. At higher resolutions, where the temporal noise approximates the intrinsic noise, we observe a decrease in both the temporal S/N and image S/N with increasing resolution. At lower resolutions physiological fluctuations dominate the overall noise thus hampering further increases in temporal S/N.

Conclusion: Increases in signal to noise by going to higher field strengths or using surface coils are best capitalized on by imaging at a resolution corresponding to the "elbow" of the curve obtained from the temporal vs. image S/N with spatial resolution relationship.

References

¹Kruger G, et al. *MRM* 2001; 46:631-37. ²Petridou N, et al. Proc *ISMRM* 2001; p. 1181. ³Hyde JS, et al. *MRM* 2001; 46:114-25.

Comprehension of Metaphors in Chinese—English Bilinguals: An Event-related fMRI Study

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Introduction: Metaphor is both ubiquitous in and central to communication, cognition and creativity. However, its neural basis is hardly known. Some neuropsychological studies^{1, 2} and a PET study³ of metaphor in English show the right hemisphere is more advantageous in metaphor processing. Considering the linguistic uniqueness of Chinese it is worth probing whether understanding metaphors in this language also shows such uniqueness. This study investigated the anatomical substrate of metaphor comprehension in Chinese-English bilinguals by with the fMRI technique.

Methods: The study adopted an event-related design using both Chinese and English materials that were presented visually. There were three conditions for both the Chinese and the English parts of the experiment: metaphorical sentences, literal sentences and meaningless sentences serving as fillers. Passive viewing of the fixation points served as the baseline. All sentences took the form of "A is B." Subjects were asked to make semantic judgment on the plausibility of the sentence.

Results: The results showed that in the Chinese part, significantly more areas were activated in the literal than in the metaphorical condition, contrary to the finding from Bottini's (1994) PET study of English metaphors. In contrast, the English metaphors yielded more activations than literal sentences and the comparison demonstrated that metaphor processing involved more of the left hemisphere, contrary to Bottini's finding that the right hemisphere is more important for metaphor processing in English.

Conclusions: Our result not only indicates that understanding Chinese and English metaphors in Chinese–English bilinguals involves different neural substrate, but also suggests that people in different cultures might have different neural mechanisms at work in understanding metaphors in their own languages.

¹Faust, M, Weisper, S, *Brain Cogn* 43 (2000) 186-91. ²Winner, E, Gardner, H, *Brain* 100 (1977) 717-29. ³Bottini, G, Frith, CD et.al, *Brain* 117 (1994) 1241-53.

Event-related fMRI Study on the Effect of One Week-long Practice in Human Problem Solving

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Introduction: Anderson et al. (submitted) proposed that several brain areas play fundamental roles in human problem solving based on fMRI experiments on algebra equation solving and simple symbolic reasoning, which are consistent with the functional roles of hypothesized buffers in the ACT-R theory. As an extension of this research, the current event-related fMRI study investigates the effect of relatively extensive practice on the activation patterns of these and other related brain regions.

Methods: The task was simple symbolic reasoning with transformation rules similar to that in basic algebra equation solving. The computational complexity was manipulated based on the number of transformations necessary to get the answer. The experiment lasted 6 days: rule learning and reasoning practice on the first day; a scan while doing the task on the second day; practice of about 1.5 hours on the third through fifth day; a second scan while performing the task on the sixth day. Both scans were with the same parameters (GE 3T, single-shot spiral, 1500 ms TR, 18 ms TE, 700 flip angle, 20 cm FOV, 28 slices) and lasted 55 minutes for 10 blocks with at least 12 trials in each block (The exact number of trials in each block depended on the speed of the participant's reasoning). There were 15 blocks in each practice session. Participants were young right-handed, native English speakers and were given incentives for better performance.

Results: The group analysis of the participants who showed clear performance improvement during practice in behavior data revealed that there was significant effect of rule complexity on regions in motor, prefrontal, and posterior parietal areas which, as proposed by Anderson et al (submitted), were associated with manual buffer (for key-press response), retrieval buffer (for rule retrieval) and imaginal buffer (for mental transformation) respectively in ACT-R model. The effect of practice on the parietal particle is minimal consistent with the idea that there is relatively little change in the number of transformations. There is greater reduction in prefrontal cortex reflecting retrieval practice. The practice effect on the motor particle is only to move the peak forward, which reflects faster latencies after practice. In addition, there was significant practice effect on a caudate particle, which is quite striking — there was a clear BOLD response initially and it was gone by the last day.

Conclusions: This study offers new evidence on the neural basis of the major components in computational models of human cognitive architecture, such as ACT-R, convergent with previous studies and enables us better understanding of the processes of learning. The reduction of caudate activity may appear inconsistent with Poldrack et al. (2001), but probably reflects the greater amount of practice that the participants had.

The Mirror System: A Mechanism to Understand the Actions of Other Individuals

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In the monkey's premotor cortex there is a class of neurons that discharge both when the monkey makes a particular action and when it observes another individual (monkey or human) making a similar action. These neurons were named "mirror neurons." In the first part of my talk, I will review the properties of mirror neurons and present data on the recently discovered "auditory mirror neurons." In the second part of my talk, I will provide evidence based on transcranial magnetic stimulation, EEG/MEG recordings and brain imaging experiments that a mirror system exists also in humans. I will show that that human mirror system includes several parieto-premotor circuits and that different actions activate different circuits according to the observed action. I will conclude proposing that we understand the actions of others because we map them on an internal representation of our own actions and that the mirror system represents the neural basis of this mechanism. I will submit also that the mirror mechanism is the precursor of our capacity of understanding the intentions of others and of some basic forms of communications.

Temporal Pole Activation during Language Processing: An fMRI Study in Epilepsy Patients who are Candidates for Left Anterior Temporal Lobectomy

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Introduction: In a previous study, we compared fMRI to intraoperative electrocortical stimulation mapping (ESM) for the localization of temporoparietal language areas. It was noted that fMRI activity was often present in the anterior temporal lobe (ATP) that was later surgically removed. This is in accordance with other functional imaging studies that found activation of anterior temporal areas, and in particular the temporal pole (TP), with processing of sentences. Although some lesion studies have reported mild postoperative language impairments in sentence comprehension, findings contrast with the clinical observation that language functions are in general not affected after surgical removal of the ATL. In this ongoing study we test epilepsy patients for TP activity before surgery. After surgical removal of ATL, the fMRI results will be compared to language function.

Method: Language-related brain activation was studied with fMRI in twelve epilepsy patients who were candidates for surgical removal of the left ATL in the language-dominant hemisphere (as established by a bilateral sodium amytal test). Both a verb generation task and a sentence comprehension task were used. The latter task has previously shown strong left-sided activation of the temporal pole (TP) in healthy volunteers.² We intended to address the following questions: (i) Do temporal lobe epilepsy patients yield a similar high degree of left-lateralized TP activity as healthy subjects?

(ii) Does a sentence comprehension task yield significantly more TP activation than single-word generation tasks as suggested in the literature? A direct comparison between these tasks has not been performed.

Brain activation was measured using a 3D BOLD technique (navigated PRESTO sequence).³ The sentence comprehension task consisted of three conditions: reading of sentences (sentences), reading of word lists (words) and a control condition where the patient viewed symbols (rest); this resulted in three different contrasts. For each patient, three volumes of interest (VOIs) were defined in each hemisphere: frontal language areas, temporoparietal language areas and the temporal pole (TP). Per VOI a lateralization index was calculated. Only the TP is discussed in this abstract.

Results: As expected, TP activation was most frequently observed in the sentences-rest and sentences-words conditions (both 10/12 patients). Although to a lesser extent, activation was also present in half of patients during the words-rest condition and the verb generation task (both 6/12 patients) suggesting that activation of the TP is not limited to syntactical and/or semantical processing of sentences.

Conclusions: Only a few patients (2/12) selectively activated the left (epileptogenic) TP with the sentence comprehension tasks, in contrast to the earlier finding that most healthy subjects activate the left TP only.[2] This may in part explain why sentence processing is relatively unaffected by unilateral anterior temporal lobectomy. Possibly, there are (subtle) language deficits in these patients that at present go unnoticed with standard clinical neuropsychological tests. We are therefore currently devising a battery of linguistic tasks that more specifically focus on possible sentence processing deficits due to the illness and due to surgical removal.

¹Rutten et al., Annals of Neurology 2002 (In Press).
²Stowe et al., Psychophysiology 1999.

³Ramsey et al., Neuroimage 1998.

Drug Efforts on Oxidative Metabolism and Cerebral Blood Flow Changes in Sensorimotor Activation

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Introduction: By combining BOLD and arterial spin tagging (AST) approaches it is possible to quantify the effects of drugs on the increases in cerebral blood flow (CBF) and cerebral metabolic rate of oxygen consumption (CMRO2) during activation. In this study the effects of indomethacin on motor activation were investigated.

Methods: Experiments were conducted on a GE I.5 T scanner. The activation protocol consisted of three sessions of finger tapping (I0 min each): twice in the absence of drug and once following the iv infusion of indomethacin (0.2 mg/kg). Eight subjects were studied. AST and BOLD data were acquired on separate days. The CBF data from the first AST session were used to define the region of interest that was used for all data analysis.

To determine the CMRO2 increase during activation, BOLD signals and CBF increases during hypercapnia are used to calibrate BOLD signals observed during activation (Davis et al., *PNAS USA* 1998;95:1834-1839; Hoge et al., Magn Reson Med 1999;42:849-863). For the hypercapnia-calibration experiments subjects inhaled a mixture of CO2/O2/N2 (6:21:74 percent) for two intervals (5 min each). Room air was inhaled for 5 minutes prior to each CO2 interval. During one interval the AST data were collected and during the other the BOLD data were collected. The collection order was randomized between subjects.

Results: Prior to indomethacin injecting, the CBF increase and the BOLD signal in the motor cortex were 31 ± 2 percent and $1.1 \pm .1$ percent respectively. The corresponding CMRO2 increase was 15 ± 1 percent (values given as mean \pm sem). In the presence of indomethacin, the activation-induced CBF increase was significantly reduced but the BOLD signal remained unchanged. The ratios of activation-induced CBF and CMRO2 increases in the presence and absence of indomethacin were $0.50 \pm .05$ and 0.8 ± 0.1 respectively.

Conclusions: The work presented here demonstrates that combined BOLD/AST approaches can be used to quantify the effects of drugs on CBF and CMRO2 increases during activation. In this case, the effects of indomethacin on motor activation were studied. This drug significantly reduced the activation-induced CBF increase and caused a small, but statistically insignificant ($p\sim0.1$), reduction in the CMRO2 increase.

The Hole Superiority Effect is Context-Dependent in Monkey Pattern Recognition

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Introduction: What feature is the beginning of pattern recognition? Two conflicting theories exist: the first, 'global precedence' was suggested by Navon (1977), the second is that of 'topological predominance' which was advanced by Chen (1982) on the basis of evidence in figure recognition in humans. In the Chen experiment subjects were asked to make same-different judgments for pairs of pictures. Subjects were more accurate for pictures that had the same shape but a difference in an inner hole compared to picture pairs with a distinct shape and no difference in the inner hole. The phenomenon was defined 'hole superiority' in pattern recognition. We have carried out the experiments in three monkeys and found that the hole superiority effect is context-dependent.

Methods: Stimuli comprised of a picture matrix with three rows and four columns. The first row had four geometric figures: ellipse, triangle, ellipse with an inner hole and triangle with an inner hole. The second and third rows had four line-drawn faces with either different eyes or mouth that where the same as the correspondent geometric figures in the first row but at a reduced size. The pictures were displayed on screen in pairs that had either a difference in the shape of the features or the shape of the hole within the features. Three experimental paradigms were performed successively whilst neuronal firing in the inferior temporal cortex (area IT) was recorded. Monkeys were trained to detect the difference between two pictures in the discriminative paradigm. In the paradigm of concurrent matching to sample, the common feature in a picture pair was the target; both common and different features are target in the same-different judgment. The learning curves were compared, then the display duration for the stimuli shortened to test the changes in the correct rate and reaction time. The relationship between the pattern of neural firing and perceived responses was compared by peri-stimulus histogram.

Results: Results from the three experimental paradigms suggested that the geometric shape played a more predominant role than hole feature; whilst the hole feature does facilitate learning of face discrimination. By reducing presentation duration of the stimuli, the detecting precedence appears to be the hole feature of the face component but the shape difference in figure recognition. The face cells and the cells sensitive to geometric figures are distributed over the IT area. The pattern of neuronal firings were consistent with pictures of faces and were dependent on the right or wrong responses, but were indifferent to facial and non-facial pictures without a hole. The phenomenon suggests that area IT receives rapid feedback from an 'executive mechanism' to the more ecologically valid face stimuli.

Conclusion: The findings in both the behavioral and neuronal studies demonstrate the hole precedence in face but not figure recognition in the monkey. The neural correlates of the context-dependent effect suggest that inferior temporal cortex receives feedback from 'executive' of the monkey brain. It remains to be tested experimentally further. We hope to further study this effect with human subjects and fMRI.

References

Laminar Specificity of fMRI Onset Times during Somatosensory Stimulation

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Introduction: Functional MRI techniques based on either changes in blood oxygenation (BOLD), regional cerebral blood flow (rCBF), or blood volume (rCBV) are having a large impact in defining regions of the brain that are activated due to specific stimuli. Along with the push to more fully analyze temporal fMRI responses there has been a push to higher spatial resolution to map sub-regions within activated areas.

Method: The rat somatosensory cortex has been an excellent model system to investigate issues related to fMRI. A number of groups have reported robust fMRI responses to forepaw stimulation with general agreement about the area activated and extent of activation. In addition, there have been careful comparisons of onset of BOLD, perfusion, and blood volume based fMRI. The neuronal innervation in the case of forepaw stimulation is well known. Afferents from the thalamus innervate the somatosensory cortex at layer IV with excitation going up to layers III-I and down to layers V-VI.

As part of an overall goal to begin to use fMRI to sort out neuronal signaling within laminar structures of the brain, we have studied onset times to forepaw stimulation in the rat somatosensory cortex. This study was conducted on nine male adult Sprague-Dawley rats, anesthetized with alpha-chloralose. Two needle electrodes were inserted under the skin of the left forepaw (in the space between digits 2 and 3 and between digits 4 and 5). Electrical stimulation consisted of pulse of 2 mA, 3 Hz, 0.3 ms. Stimulations were time-gated to the image acquisition. BOLD fMRI was obtained at 40 ms temporal resolution and spatial resolution of 200 x 200 x 2000 microns using a gated activation paradigm in an II.7T MRI. The time-course of activation was analyzed carefully for the onset of activation.

Results: Our results clearly indicate a significant and consistent heterogeneity of onset times, with the earliest activated regions corresponding anatomically to layers IV-V. In addition, they show that fMRI has enough spatial and temporal resolution, as well as sensitivity, to differentiate between different functional layers of the cortex.

Conclusions: Furthermore, it indicates that the hemodynamic response follows the functional organization of the cortex, as most of the thalamocortical fibers project to granule cells in layer IV. These results open up the possibility of using fMRI to monitor laminar communication within areas of the brain.

Brain Structures Responsive to Mastering a Complex Motor Skill

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Introduction: Knowledge of neural regions crucial to transforming action goals into signals that support complex sequenced movements has been studied extensively. The way in which these brain systems respond to extensive practice and come to implement high-level, expert motor skill is less well known. A key question is whether the same brain structures remained involved through the different stages of learning and a form of adaptation occurs (e.g., neural recruitment, neural dedication) or, in contrast, whether various brain structures "turn off or on" and a new circuit is formed as a function of factors such as automaticity (e.g., reduced resource utilization) or compositional changes (e.g., collapsing/reducing the action steps).

Method: To address this question we trained subjects on a set of complex motor tasks (tying knots) and examined brain activation change. The knot tying task served as stimulation at I.5 tesla in a repeated measures design (pre- and post-training fMRI scans; 5 sessions of intervening training) with I5 normal healthy controls. Analyses focused on activation change associated with specific learning patterns(strong skill improvement, weak improvement, no improvement).

Results: The key result was that Strong Learning (pattern of incorrect performance at session I; correct at session 2 with a 33 percent drop in time-to-completion) produced activation increases in posterior cingulate and precuneus. In contrast, the pattern of No Learning (performance failures at both the pre and post training scanning sessions) produced increases in anterior cingulate, DLPFC, and SMA — areas well-associated with declarative aspects of learning.

Conclusion: The results for the Strong Learning (increases in posterior medial structures) are considered to reflect a change in resource allocation and reduced monitoring and effort, as part of the mechanism that permits dual processing by "freeing up" anterior structures to take on the new, second task. Thus, these posterior structures are proposed to implement a form of "Non-Executive Monitoring" and attention, that are crucial to the shift to expertise and the eventual development of automaticity.

Love and Lust in the Male Brain

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Introduction: Functional Magnetic Resonance Imaging (fMRI) and Positron Emission Tomography (PET) techniques have offered new insights into human processing of sexual arousal¹ and have allowed the emergence of research in the biology of love.² Based on this and earlier work with animals and humans, a model of sexual arousal describing brain processes mediating perceptual-cognitive, emotional, motivational and physiological components has been proposed.¹ We test the hypothesis that feelings of romance involve the former three of these components, but not the same physiological components as sexual arousal.

Method: Whole brain fMRI scans were taken from nine healthy males viewing images that were previously shown to evoke subjective feelings of: Lust (explicit slides) or Romance (Romantic slides) or little/no subjective affective response (neutral slides). SPM software was used to contrast explicit and romantic with neutral slides as well as with each other.

Results: Contrasted with neutral slides, images that evoked feelings of lust showed activation in the following regions: bilateral occipitotemporal, bilateral cerebellum, right anterior cingulate, right precuneus, right orbitofrontal gyrus, left precentral gyrus, right middle frontal, left anterior superior temporal gyrus, hypothalamus, and brainstem. Romantic images, when compared with neutral slides, showed greater activation in left cerebellum, right occipitotemporal, right precuneus, left cuneus, bilateral orbito frontal, bilateral middle frontal, left precentral, left amygdala/uncus, left posterior hippocampus and left striatum. No activation was found in anterior cingulate, hypothalamus or brainstem for romantic slides. Contrasted with romantic slides, explicit slides showed greater activation in bilateral occipitotemporal, right precuneus, left cuneus, hypothalamus and brainstem regions, and less activation in the amygdala, insula, and left cerebellum.

Conclusion: Results suggest that, in comparison to feelings of lust, romantic feelings evoked by visual stimuli require less involvement from areas involved in physiological or endocrinological processing, but greater processing in emotional/social systems.

References

¹Redoute (2000) Hum Brain Mapp II(3): 162-77. ²Bartels A, Zeki S. (2000) Neuroreport II(17):3829-34.

Why the sad face? Clinical Depression and the Overactive Brain

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Introduction: Imaging studies of healthy subjects have found visual cortical activation in response to emotional compared with non-emotional signals (Lane et al., 1999) that was not associated with the visual complexity of the stimuli (Taylor et al., 2000). Based on neuropsychological findings in depression, demonstrating negative bias in perception of emotional signals (Gur et al., 1992), we expected that the fMRI experiments could elucidate the neural correlates of these bias.

Methods: Nine patients with unipolar depressive disorder (DSM-IV) and nine healthy controls underwent event-related fMRI. In each of the scanning tasks the subjects were presented with ten different facial identities expressing 50 percent and I00 percent intensities of one emotion (either sadness, happiness, disgust or fear), in addition to a neutral expression. We employed orthogonal polynomial trend analysis and compared the trends between the groups using voxel-and cluster-wise ANCOVA.

Results. Compared to controls, the patients demonstrated significantly stronger activation in response to 100 percent sad expressions vs. neutral faces. Cortical responses to other three emotional stimuli (happiness, disgust and fear) were lower in patients—relative to controls. Additionally, the patients had greater trends (relative to the controls) to increase the intensity of visual cortical and cerebellar activation when they were processing increasing intensities of sad expressions. Conversely, the trends in neural responses to happy, fearful or disgusted expressions were greater in controls than in patients.

Conclusions: We were able to demonstrate stronger bias in depressed patients towards processing the visual stimuli of emotionally congruent nature, i.e., sad facial expressions. These neural responses may contribute to the mechanisms of depression.

References

Lane RD, Chua PM, Dolan RJ (1999) Common effects of emotional valence, arousal and attention on neural activation during visual processing of pictures. Neuropsychologia 37: 989-97.

Taylor SF, Liberzon I, Koeppe RA (2000) The effect of graded aversive stimuli on limbic and visual activation. *Neuropsychologia* 38: 1415-25. Gur, R. C., Erwin, R. J., Gur, R. E., Zwil, A. S., Heimberg, C. & Kraemer, H. C. (1992). Facial emotion discrimination: II. Behavioral findings in depression. *Psychiatry Research*, 42, 241-51.

Reduced Neural Activation in Parkinson's Disease: An Event-related fMRI Study of Processing Speed

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Introduction: Parkinson's disease (PD) is characterized by a dysfunction of dopamine systems that compromises the striatum and motoric functions. In addition, PD patients have greatly reduced psychomotor processing speed. The Digit-Symbol Substitution Test (DSST), modified from the Wechsler Adult Intelligence Scale is a task sensitive to individual differences in processing speed. The present study aimed to examine the underlying processes involved in the DSST in Parkinson's patients and age-matched controls. We used event related functional Magnetic Resonance Imaging (fMRI), allowing for interpretation of individual trials based on subject performance.

Methods: On each trial participants saw an "answer key," and a set of digit-symbol pairings, across the top of the screen. In the answer key, the digits I to 9 appeared with a set of nonsense figures below them. The task was to determine whether the pairing that appeared below the answer key matched (right-index button press) or did not match (right-middle button press) on of the entries in the answer key. The answer key was randomized at each trial. Participants performed 25 DSST-match, 25 DSST-non-match, and 25 fixation trials; randomly presented at a fixed duration of 4 seconds with a 250 msec ISI.

Results: Reaction time and accuracy did not significantly differ between groups. Despite comparable performance on behavioral measures of the DSST, fMRI BOLD signal decreased markedly in PD patients compared to controls at all regions of interest examined, including BA9, 44, 46, 40/7, and caudate nucleus.

Conclusions: These results suggest specific PD-related frontal-striatal dysfunction and its relationship to processing speed. Results from both total DSST trials and successful trials may indicate that dopaminergic dysfunction in the striatum affect neural function in PD, or that changes in PD affect the hemodynamic response function (HRF) independent of performance. Regardless of performance on processing accuracy and speed, PD patients show greatly reduced BOLD activation in areas activated by the task in younger individuals and healthy elderly.

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Hemodynamic Responses in Humans to the Perception of Compatible and Incompatible Body Motion

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Introduction: Primate single cell electrophysiological studies have reported neurons in temporoparietal cortex that integrate both body form and motion direction.^{1,2} Cells selectively responsive to motion direction compatible with profile direction (e.g., left profile moving left) were more than twice as numerous as cells selectively responsive to incompatible motion direction (e.g., left profile moving right).² Here we report a preliminary study examining human hemodynamic responses to the perception of compatible and incompatible body and head motion.

Method: Five patients, aged 25-56 (I male), being investigated for seizure surgery viewed videos of human motion. Stimuli were profiles of: (A) a head moving in a compatible direction (i.e., left profile moving left, right profile moving right); (B) a head moving in an incompatible direction (i.e., left profile moving right); (C) body profile moving in a compatible direction; and (D) body profile moving in an incompatible direction. Conditions occurred in ABCD sequence interspersed with an amorphous shape moving in left and right directions matched for luminance, contrast, and size, to the body and head stimuli. Block duration was 12 seconds. The ABCD sequence was repeated three times (total imaging run time = 288 seconds). Two imaging runs were used. Whole brain MRI data were acquired at 3T (GE MRI scanner). A series of oblique axial gradient echo echoplanar volumes were acquired during visual stimulation using the following parameters: TE=40, TR=2000, flip angle=40, NEX =1, FOV=25, matrix=128x128, number of slices=14, slice thickness=6mm, skip=1.5mm. Data were realigned, slice timing adjusted and normalized using SPM99. Parameter estimates were determined using the General Linear Model. Contrasts were calculated for compatible and incompatible motion for both head and body (uncorrected p<0.001; cluster threshold=4). Fixed effects and conjunction analyses were performed in this preliminary investigation.

Results: Examination of single subject data revealed greater responses to incompatible motion relative to compatible motion, particularly for the body. A conjunction analysis revealed a greater response in right superior temporal gyrus (Talairach coordinates x=60, y=0, z=0), left inferior frontal gyrus (x=-30, y=12, z=-15), right cingulate gyrus (z=15, y=-3, z=30), and left caudate (z=-12, z=-12) to incongruent body motion compared to congruent body motion that was consistent across the five subjects. The comparison between congruent and incongruent head motion did not survive cluster threshold.

Conclusions: In contrast to primate single cell studies,² the present findings indicated a greater response to incompatible motion when compared to compatible motion, especially for motion of whole bodies. The pattern of neural responses may in part reflect activation due to the increased novelty or salience of the incongruent body motion stimuli.³

References

¹Oram MW, Perrett DI. (1994) *J Cog Neurosci* 6:99-II6. ²Oram MW, Perrett DI. (1996) *J Neurophysiol* 76:I09-29. ³Downar J, et al. (2002). *J Neurophysiol* 87:615-20.

Mechanisms of Visual Attention in the Human Brain

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A typical scene contains many different objects that compete for neural representation due to the limited processing capacity of the visual system. Evidence from functional brain imaging studies in humans indicates that the competition among multiple objects for representation in visual cortex can be biased by both bottom-up sensory-driven mechanisms and by top-down influences. For example, stimulus salience, such as a stimulus of high contrast, provides a bottom-up bias favoring neurons that represent the salient stimulus at the expense of less salient stimuli. Top-down influences on visual cortex, as in the case of selective attention, can also bias the competition and even override sensory-driven inputs. Biasing signals due to selective attention can affect neural processing in several ways, which include: I) the enhancement of neural responses to attended stimuli; 2) the filtering of unwanted information by counteracting the suppression induced by nearby distracters; and 3) the biasing of signals in favor of an attended location by increases of baseline activity in the absence of visual stimulation. Thus, attentional modulation of activity in visual cortex can occur not only in the presence, but also in the absence, of visual stimulation. Although the competition among objects for representation is ultimately resolved within visual cortex, the source of top-down biasing signals derives from a network of areas in frontal and parietal cortex. Attention-related activity in these areas does not reflect attentional modulation of visually evoked responses, but rather the attentional operations themselves. Ultimately, the object that wins the competition for representation in visual cortex will gain further access to memory systems for mnemonic encoding and to motor systems for guiding behavior.

Short Echo Time fMRI, Mesiotemporal Tissue Signal and BOLD Sensitivity

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Introduction: FMRI studies on amygdala are often problematic due to susceptibility artifacts that cause dramatic signal loss near the nasal cavity. We developed a 3D fMRI protocol to reduce this problem, making use of a short ech time (19 ms). This echo time is rather short compared to T2* of neocortical tissue(70 ms), so it may result in reduced sensivity for brain activity. The purpose of the present study was to test this technique for I) success at preserving tissue in amygdala, 2) sensitivity for BOLD effects in primary cortex, 3) idem for mesiotemporal activity. We conducted an emotional processing study to address these issues. Emotional processing is thought to be mediated by neural circuits involving the frontal cortex, cingulate cortex, insular region, thalamus and the amygdala-hippocampal area. We used pictures of the IAPS (international affective picture system). By visually presenting these pictures we expect to find strong activity in the visual cortex, but also activity evoked by emotional processing (e.g., in the amygdala).

Method: Eight healthy subjects (four male, four female) participated. A blockdesign was used which consisted of eight trials with I20 affective pictures (positive, negative and neutral pictures). Each trial consisted of 5 positive, 5 negative and 5 neutral pictures. The pictures were presented for 5 s. All pictures were matched on arousal. We used a multishot 3D echoplanar sequence with the following parameters: TE/TR=19/29 ms, FOV 256*256*120, Flip 9.5, matrix 64*64*30, scantime 3.26 s, 3 shots per slice, SNR 95. Scans were acquired in a single run of 320 scans (I040 s).

Results: Signal in tissue near the nasal cavity was well preserved due to the short echt time. By comparing neutral pictures to the rest condition we found strong activity in the visual cortex. Visual processing activity was detected in all subjects, indicating good sensitivity for "hardwired" neuronal activity. To assess sensitivity to amygdala activity, we contrasted positive pictures to neutral pictures. This showed activity in the following areas: the frontal cortex, anterior cingulate cx, insula, the parahippocampal and middle temporal gyrus and also in the amygdala. The negative affective pictures relative to neutral pictures also increased activity in frontal areas, anterior cingulate and the amygdala-hippocampal area.

Conclusions: Our results show that with a short echotime fMRI technique activity can be detected in cortical and sub-cortical areas which are thought to be involved in the emotional neural circuit. In future studies we will compare this technique to other fMRI techniques to further assess the qualities of this technique for amygdala imaging.

Lang, PJ, Bradley, MM and Cuthbert, BN. The international Affective Picture System (IAPS): Photographic Slides. Gainsville: University of Florida;1995.

The fMRI Data Center: Developments and Directions

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Investigations using fMRI continue to crystallize thinking on the roles that various brain regions play in learning, memory, vision, and behavior. The fMRI Data Center (http://www.fmridc.org) seeks to archive complete raw data sets from peer-reviewed fMRI studies of these cognitive phenomena, making the data publicly available for confirmatory and novel analyses by other researchers. This presentation will discuss the role of the fMRIDC in serving as an archival resource of published fMRI studies, describing the current status of the fMRIDC effort, and the directions for the future. In particular, we will discuss the recent outcome of a recently announced research award to recognize novel approaches in the reanalysis of published fMRI data. Additionally, we will present recent research concerning descriptive measures for fMRI time course dynamics that are I) easy to interpret, 2) computationally efficient, 3) are useful for rapid inspecting the data from a functional imaging run, and 4) are not dependent upon the experimental design, per se. Such measures may also be useful in the examination of data across individual studies by clustering methods^{1, 2} which may facilitate the identification of brain activation patterns not discernable on the basis of a single study alone. All in all, the fMRIDC endeavors to play a key role in the advancement of cognitive neuroscience by enabling researchers both with cognitive neuroscience and from other fields to inspect published data thereby helping researchers to generate novel hypotheses and ideas for further functional neuroimaging experimentation and the advancement of cognitive neuroscience.

¹C Goutte, LK Hansen, MG Liptrot, E Rostrup, *Hum Brain Mapp* 13, 165-83 (2001). ²C Goutte, P Toft, E Rostrup, F Nielsen, LK Hansen, *Neuroimage* 9, 298-310 (1999).

Automatization and Information Processing Capacity

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Introduction: Behavioral studies have shown that practice of a cognitive task can increase speed of performance and reduce variability of responses and error rate (I). Improved performance after practice reflects a shift from controlled to automatic processing. Previous research has shown that automatization leads to a reduction of brain activity in regions associated with working memory (WM) (2). Thus, practice seems to enhance efficiency of brain structures involved in cognitive activity and allow for a reallocation of limited processing resources. In this study we assessed the relationship between practice-induced changes in brain activity and the capacity to perform multiple tasks. We hypothesize that the degree to which brain activity is reduced, predicts the ability to reallocate processing resources to additional tasks.

Method: Twelve healthy controls (seven male, five female) participated in the experiment. The primary task was a verbal Sternberg task with two conditions; a novel task (NT) and a practised task (PT). In the NT, the target set was continuously changed. In the PT, the same set was used each time. The PT was trained for 25 minutes before scanning. After scanning the task was repeated, and was then administered concurrently with a tone detection task. We acquired fMRI data, using the three-dimensional (3D) PRESTO fMRI sequence (3). FMRI data analysis involved three steps, including regression-analysis of the tasks, group analysis of the NT to identify WM regions, and analysis of variance of the mean activity levels during NT and PT. The increase in errors on the primary task due to addition of the second task was used as a measure of multitasking ability.

Results: Performance data on the Sternberg task during the scan session revealed that reaction time on PT was decreased compared to NT(p<.001). After practice, brain activity was significantly reduced in the working memory network, i.e., left prefrontal, bilateral parietal and anterior cingulate cortex, and left fusiform gyrus (NT minus PT, p<.001). During the dual task, accuracy on the Sternberg task was significantly decreased compared to the single condition (p<.001). This decrease was negatively correlated with the degree of reduction in brain activity (r=-.77, p=.003). Improvement of reaction time in the single task did not seem to predict the impact of a second task to Sternberg performance.

Conclusions: The ability of individuals to process a demanding cognitive task simultaneously with a second cognitive task is associated with a neurophysiological change in brain activity following practice of the single task. Subjects who display a large reduction of brain activity during automatization of cognitive processes involved in working memory, are better at multitasking than subjects who display a slow or limited reduction. Reaction time was not a good predictor of multitasking. We hypothesize that practice induces two independent phenomena. First, it improves efficiency of processing a single task. Second, it disengages neurons from participation if they are not critical for the task.

Neural Correlates of Spatial Negative Priming: An Explorative fMRI Study

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Introduction: Spatial Negative Priming (NP) refers to the increase in reaction time (RT) in response to a target which is presented on a location previously occupied by a distractor stimulus. This effect is commonly observed in healthy controls [I], whereas schizophrenic patients generally show no (spatial) NP [2]. In this explorative study, we aim to identify the brain regions involved in spatial NP in healthy controls. Future studies will investigate brain activity in schizophrenic patients, to identify anatomical abnormalities underlying their deficit.

Methods: We acquired event-related fMRI data from 16 healthy students (eight males/eight females), using a fast 3D BOLD-sensitive imaging technique (PRESTO, [3]). On the screen four circles were presented. Each trial consisted of the presentation of two dots of different sizes within these circles. Subjects had to press the button which corresponded with the location of the largest dot (i.e., target). Three conditions were tested: (a) control trials, in which the two dots were presented on two previously unoccupied locations, (b) distractor repetition, in which the small dot (i.e., distractor) was presented on a location previously occupied by a distractor, and (c) SNP, in which the target was presented on a location previously occupied by a distractor. Trials were spaced I.5 seconds apart, but trials from the same condition were randomly interspersed. FMRI data was analysed using SPM99 (Welcome Dept., London).

Results: Accuracy was above 90 percent and did not differ between the conditions (F(2,14) = 0.347, p = .713). RT on control trials was faster than on spatial NP trials (t(15) = 5.785, p < .0001), but slower compared to distractor repetition trials (t(15) = 3.05, p = .008). In all conditions activation was seen in the left motor areas, and bilaterally in parietal and occipital lobes. The contrast image SNP versus control was thresholded at t = 3.79 (p = .001 uncorrected) and revealed increased activation in the superior frontal gyrus (BA9), middle frontal gyrus (BA10), and middle occipital gyrus (BA18) on the left side of the brain.

Conclusions: The task shows that in processing visual stimuli, relevant and irrelevant information is distinguished. In particular, if the location of a target coincides with the previous location of a distractor, speed of responding is reduced. We found three areas that activate more during SNP relative to control. The frontal areas are hypothesized to be involved in memory and subsequent interference solution, whereas the visual area is possibly involved in redirecting attention towards the target location.

References

Tipper, SP. The negative priming effect: inhibitory priming by ignored objects. QJ Exp Psychol [A] 37, 571-90 (1985). Vink, M, Ramsey, NF & Kahn, RS. Do schizophrenic patients have an inhibition deficit? A review. In preparation. Ramsey, NF et al. Phase navigator correction in 3D fMRI improves detection of brain activation: quantitative assessment with a graded motor activation procedure. Neuroimage 8, 240-48 (1998).

An fMRI Investigation of Executive Function in Major Depression

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Introduction: Behavioral studies have shown that depressed patients have impairments in a number of cognitive domains. Such impairments are more often evident in tasks involving effortful as opposed to automatic processing. In particular, executive tasks involving goal-directed processes are particularly implicated in the neuropsychological profile of depressed patients. In this study executive processes were assessed using the Trail Making Test, a classic neuropsychological measurement of 'frontal lobe function,' with the Trails B task revealing impairments in depression (Austin et al., 1999). Task difficulty was graded over four conditions with increasing cognitive, strategic demands, ranging from automatic cued motor movements to self-generated number sequencing and then to number and letter sequencing, which requires the additional executive processes of planning, attentional set-shifting and integration. As well, we expected that with modification of this task for fMRI, additional demands of motor control and skill learning would be elicited.

Methods: 240 T2*-weighted images were acquired from each of 16 non-contiguous axial planes (TR 2000ms, TE 40ms) on a 1.5 Tesla GE Signa System. 10 non-medicated patients with a DSM-IV diagnosis of major depressive disorder, no-comorbid disorders, (7F; mean age 40.1 years) and 10 healthy dextral subjects (7F; mean 39.6 years) performed: (A) motor control task; (B) Trails A; (C) Trails B; and (D) rest, presented in a blocked ABCD design, counter-balanced order, with 30 second epochs for each condition, and 4 repetitions of each block over a total of an 8 minute experiment.

Results: The neural correlates of all three experimental conditions revealed significant BOLD responses in the right cerebellum, left precentral gyrus, left inferior parietal lobe, and anterior cingulate in both groups. Trails B showed a greater BOLD response in the lateral and medial frontal gyrus and caudate as compared to Trails A. With the Trails A task, depressed patients showed increases in the frontal pole and superior medial frontal regions and decreases in the parahippocampal region, cerebellum and basal ganglia as compared to controls. With Trails B, patients showed increases in superior medial frontal regions and decreases in the subgenual anterior cingulate, inferior frontal, insular and parahippocampal regions, caudate and cerebellum as compared to controls.

Conclusion: The processing demands the Trails Making Task, which requires externally focused attention to plan and update novel, non-automatic sequences, appear to be associated with recruitment of the lateral and medial prefrontal cortices, caudate and medial temporal lobe. However, different cerebral regions were recruited by the groups during the Trails B task, which may reflect greater cognitive flexibility and less effortful task demands for controls in contrast to depressed patients.

Reference

Austin, MP, Mitchell, P, Wilhelm, K, Parker, G, Hickie, I, Brodaty, H, Chan, J, Eyers, K, Milic, M, & Hadzi-Pavlovic, D. (1999) Cognitive function in depression: a distinct pattern of frontal impairment in melancholia? *Psychol Med* 29(1), 73-85.

Complementary Maps of the Mind

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The availability of different methods for investigating cognitive functions presents the neuroscientist with many ways of assessing brain processes. A choice that has to be made in the context of any given research question is that of which technique yields the type of information that best addresses the experimental goals. One approach is to optimise spatial and temporal resolution as much as possible and pursue ever more refined micro-measures of function. An alternative is to view each technique as occupying a unique problem space and as therefore having a distinct functional resolution. I will discuss the way in which choice of technique can determine the direction of research and how what may appear to be theoretical disputes are confusions between the different problem spaces defined by techniques. I will introduce the technique of transcranial magnetic stimulation, its advantages and limits and discuss the ways in which it can be used to challenge or support findings obtained with other methods, in particular fMRI. The examples used will be taken from studies of vision and cortical interactions. I will also discuss ways in which TMS and fMRI can be used in conjunction.

Genetic Variation and the fMRI Response

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The era of human gene discovery is rapidly unfolding, but one of the future challenges will be understanding the implications of genetic variation on brain function. This is the realm of in vivo functional genomics, which will provide important insights into variations in human brain capacities, physiological responsivities, and disease susceptiability. A functional assay of brain physiology, such as performed with fMRI, offers unique information that may be useful as target phenotypes for understanding the functional implications of genetic variation. We have performed a series of studies of prefrontal, hippocampal, and amygdala information processing as phenotypic targets for analysis of the effects of functional polymorphisms in candidate genes related to the biology of these processes. We have found:

I) a functional variation in the gene for COMT predicts the efficiency of prefrontal information processing during working memory and in the prefrontal response to amphetamine during working memory; 2) A functional polymorphism in the gene for BDNF affects the activity of the hippocampus during working memory; and 3) a functional polymorphism in the gene for the serotonin transporter effects the activity of the amygdala during the processing of emotional stimuli. These studies and initial evidence for gene-gene interactions in some of these processes will be described.

A Neural Substrate for Interpreting Social Interaction

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Introduction: Previous studies have shown that naming objects from different semantic categories is associated with distinct patterns of cortical activity. Moreover, the location of these activations suggests that they reflect activation of sensory- and motor-related features and attributes. Specifically, activation in regions of ventral temporal cortex may be associated with stored representations of object form, activation of lateral temporal cortex may reflect stored information about object motion, and activation of premotor cortex may reflect stored sequences of motor movements associated with an object's use. This study was designed to explore whether similar patterns of semantic category-related activity would be found for more abstract representations.

Methods: Subjects were presented with short, animated vignettes depicting either a social scene (e.g., playing baseball, sharing ice cream), a mechanical scene (a bowling ball knocking over pins, a factory conveyer belt), random motion, or static images. Importantly, the objects in all the animations consisted entirely of simple geometric forms (circles, rectangles, triangles, etc.). During each of four fMRI runs, subjects saw ten 30-sec blocks. Four blocks consisted of meaningful vignettes (two social, two mechanical). At the conclusion of each meaningful animation, subjects indicated their interpretation of the scene by choosing among four written alternatives. At the conclusion of the random motion (four blocks) and static images (two blocks) conditions, subjects pressed a button indicated by a response screen. Conditions were presented in pseudo-random order, with alternating blocks of meaningful and control conditions. Subjects were scanned using gradient-echo, echo-planar imaging (1.5 Tesla, TR= 3 sec).

Results: Subjects (N = 12; six female, age range 23 to 34) were highly accurate at interpreting the scenes (> 95 percent correct). Analyses of the fMRI data revealed three main findings. First, direct comparison of the social and mechanical conditions showed patterns of activity highly similar to previously reported object category-related activations. Specifically, viewing and interpreting social vignettes was associated with bilateral activation of the lateral region of the fusiform gyrus and the posterior region of the right superior temporal sulcus (STS). Similar findings have been reported for studies using pictures of human faces and animals. In contrast, mechanical vignettes were associated with activation of the medial region of the fusiform gyrus and the left middle temporal gyrus, as previously reported for tasks using pictures of tools.

Conclusion: Thus, the location of the activations depended on the subjects' interpretations of the stimuli (social interaction or mechanical action), rather than their physical form. Second, viewing and interpreting social vignettes was associated with activity in regions previously implicated in studies of social cognition. These included the more anterior regions of right STS, right anterior temporal, and right ventromedial prefrontal cortices. Finally, within area MT (defined by comparing random motion versus static images), meaningful object motion (social and mechanical) produced larger responses than random motion of the same stimuli, thus suggesting top-down modulation of MT activity.

Brain Regions Responsive to the Perception of Human Motion

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Introduction: Multiple neuroimaging studies indicate that human temporoparietal cortex responds to the perception of moving human form. This includes perception of Johansson body and hand motion, and real images of hand and facial movement. Here we report data in response to viewing movements of face, body and hand within the same experiment.

Method: Six patients, aged 24 to 56 (2 males), being investigated for seizure surgery viewed videos of human motion. Stimuli were: (A) a face with mouth opening and closing; (B) a hand opening and closing; and (C) a body stepping forward and back. Static controls existed for each body part. Conditions occurred in ABC sequence interspersed with the relevant stimulus control block. Block duration was 12 seconds. The ABC sequence was repeated four times (total imaging run time = 288 seconds). Two imaging runs were used. Whole brain MRI data were acquired at 3T (GE MRI scanner). A series of oblique axial gradient echo echoplanar volumes were acquired during visual stimulation using the following parameters: TE=40, TR=2000, flip angle=40, NEX =1, FOV=25, matrix=128x128, number of slices=14, slice thickness=6mm, skip=1.5mm. Data were realigned, slice timing adjusted and normalized using SPM99. Parameter estimates were determined using the General Linear Model. The contrast between all motion types and all static controls, as well as contrasts between each movement type and its respective control were calculated (uncorrected p<0.001). This was performed for each subject individually (cluster threshold=4), as well as for the group as a whole (cluster threshold=9). Fixed effects and conjunction analyses were performed in this preliminary investigation.

Results: Examination of single subject data revealed consistent activation overlying the superior temporal sulcus (STS) region to the motion vs static comparison. The fixed effects analysis also revealed activation overlying left (Talairach coordinates x=45, y=-51, z=6) and right (x=-47, y=-55, z=8) STS regions for the motion vs static control comparison. These regions are consistent with those reported in previous studies (4-5). For the moving vs static body comparison, activation was seen overlying left (x=-42, y=-48, z=9) and right (x=45, y=-45, z=27) STS regions. Activation to face and hand conditions was more variable and less extensive in single subjects, not surviving the chosen cluster threshold in the group analysis. Conjunction analysis revealed activation in STS regions (x=-52, y=-58, z=12) and inferior frontal regions (x=45, y=9, z=42) for the motion vs static controls comparison.

Conclusions: The data in this preliminary study indicate that bilateral STS regions respond to perception of face, hand and body motion. Body motion alone also evoked a response in regions overlying the STS. We plan to use this data to form regions of interest for the analysis of a further 12 subjects.

References

¹Allison T, Puce A, McCarthy G. Trends Cog Sci 2000, 4:267-78.

²Bonda E, et al. *J Neurosci* 1996, 16:3737-44.

³Rizzolatti G, et al. Exp Brain Res 1996, 111:246-52.

⁴Grafton S, et al. Exp Brain Res 1996, 112:103-11.

⁵Puce A, et al. *J Neurosci* 1998, 18:218-19.

Physics, Pirouettes and Philosophers: A Primer on MR Physics

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This introductory talk will lead the audience through the basics of performing an MR experiment. The fundamental hardware requirements (e.g., magnet, RF, brain, etc.) will be considered and the NMR phenomenon will be explained by means of a series of virtual and hopefully "real" spin physics animations. This interactive talk should "limber up" the audience for later, much better and far more relevant presentations but is intended to raise a few laughs as well as the audience awareness of the limitations and the strengths of magnetic resonance techniques. The core pulse sequences used to generate MR imaging data will be reviewed and a brief explanation of relaxation characteristics and the BOLD contrast mechanism will be introduced. The speaker will lead the audience through the basics of preparing for your first, simple fMRI experiment and the potential pitfalls that the experimenter will need to avoid.

Cortical Processing of Chinese and English Words by Early Bilinguals

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Introduction: A controversial issue in the literature is how different languages are represented in the brain. Some researchers have suggested that distinct cortical areas are involved in the processing of different languages. However, there is also evidence showing that the same cortical regions are activated when bilinguals accessed their native and second languages. The present study examined the cortical organization of Chinese-English bilinguals using fMRI. In contrast to most of the bilingual research that was based on data from late bilinguals, early bilinguals were recruited as our subjects.

Methods: Ten right-handed health university students (five male; five female) participated in the study. All of them acquired both Chinese and English simultaneously before age 6 and both languages are regarded as their native languages. In a block design, subjects listened to a pair of monosyllabic Chinese or English words on each trial and were required to judge whether they were semantically related. In a baseline condition, a pair of Dagaree words (an African language) was presented and subjects were asked to press the buttons randomly. The stimuli were digitized and delivered binaurally by using a Resonance Technology (Van Nuys, CA) system. The fMRI experiment was performed on a 1.5 T scanner (Siemens, Germany). A T2*-weighted gradient-echo EPI sequence was used, with the slice thickness = 5 mm, in-plane resolution = 3.3 mm x 3.3 mm, and TR/TE/FA= 3000 ms/60 ms/90 degree. Twenty-four contiguous axial slices were acquired to cover the whole brain. Data were analyzed by use of SPM99 implemented in MATLAB. All images were aligned and spatially normalized into the MNI standard brain. Each image was smoothed to increase signal to noise ratio using Gaussian filter (FWHM=8mm3). Subjects were treated as a random effect and the comparison between the experimental and baseline conditions was done by t-test.

Results: Subtraction comparisons were made between the experimental conditions (i.e., Chinese and English conditions) and the baseline condition. The left infero-middle frontal gyri and the left middle temporal gyrus mediated the processing of both Chinese and English words (p=0.0001, uncorrected), suggesting that the activation areas for the two languages highly overlap. The left thalamus and right inferior frontal cortex were activated in the English condition only.

Conclusions: Developing further the work of Kim et al using visual stimuli, our study found that the processing of Chinese and English words presented auditorily was commonly mediated by the left frontal cortex in early bilinguals. Although Chinese differs markedly from English in its phonological and semantic systems (e.g., its tonal and morphological nature), cortical activations of these two languages in early bilinguals are highly interactive. It is clear that the language center of early bilinguals is developed under the influences of both Chinese and English.

References

¹Gandour J, et al. (2000) J Cogn Neurosci 12:207-22. ²Kim K, et al. (1997) Nature 288:171-74. ³Klein D, et al. (1999) NeuroReport 10:2841-46.

An fMRI Study of Speed Reading

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Introduction: Given the same script, trained speed-readers read much faster than untrained readers. An fMRI study was performed to uncover the underlying neural mechanism of speed-reading by comparing the speed-readers and untrained normal readers during paragraph reading.

Method: Subjects were seven trained speed-readers and seven untrained normal pace readers. For trained speed readers, a fairly long paragraph (containing approximately I00 words) was presented each time for 2.5 seconds with an ISI (interstimulus interval) of 0.5s in one condition (the speed reading condition) and I2 seconds with an ISI =3s in another condition (the normal pace reading condition). For untrained readers, they only performed the latter task. In all conditions, a single fixation "*" served as the baseline. Each subject was asked to judge if there was a contextually irrelevant sentence in the stimuli. The study adopted a block-design. The scan parameters were: T2 (EPI): TR/TE = 3s/65; FOV: 240mm'240mm; image matrix: 64'64'12; T1: FOV: 240mm'240mm; image matrix: 256'256'60. The AFNI software was used for data processing.

Results: For speed readers, the comparison between paragraph-reading with fast and normal pace demonstrated activation in bilateral medial frontal (GFd, BA 6), IPL / supramarginal gyrus (GSm, BA 40), right superior parietal lobulus (SPL, BA 7), right superior temporal gyrus (GTs, BA 22) and anterior cingulate gyrus (GC, BA32), indicating that speed reading recruits more areas. The comparison between trained speed readers and untrained readers during normal pace reading showed activation in bilateral GFd (BA 6), inferior frontal gyrus (GFi, BA 44/45/46), medial frontal gyrus (GFm, BA 10), right precentral gyrus (GPrc, BA 4/6), bilateral GTs (BA 22), SPL (BA 7) and right parahippocampus (GH), suggesting that speed readers might have recruited more cognitive resources than untrained readers did, probably because they might have voluntarily or involuntarily adopted the speed reading strategy even during normal pace reading. A further multiple linear regression analysis of reading speed and the span of memory in speed readers' speed-reading data indicated that the right GFm (BA 10/11, r >0.75), GFd (BA 6/8, r >0.70) and GC (BA 32, r>0.70) were correlated with reading speed and the left precuneus (Pcu, BA 7, r <-0.65) was correlated with memory span of the subjects.

Conclusion: Our results suggested that compared with normal pace reading, speed-reading involved more brain areas, suggesting that different cognitive strategies were involved in the two modes of reading. In addition, our results suggested that reading speed correlates with the right GFm/GFi (BA 10/II), GFd (BA 6/8) and GC (BA 32) and reading speed correlates with the left PCu (BA 7).

Stereotactic Navigation with fMRI in Brain Tumors Adjacent to Motor Cortex

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Introduction: The purpose of this study was to determine a possible role of fMRI in stereotactic navigation applied to tumors adjacent to motor cortex, and to demonstrate the postoperative motor deficit rate.

Methods: Fifteen patients undergoing resective surgery for a tumor proximal to the motor cortex were scanned. The patients were asked to clench their fingers of the contralateral hand according to tumor during the activation period. fMRI images were obtained with a I.5 T MR unit using the EPI GRE sequence with a slice thickness of 5 mm including the primary motor cortex. Maximal and minimal distance between the tumor and the eloquent cortex were 2 cm and 7 mm respectively. Activation maps were superimposed on to conventional MRI scans and these maps were projected on to the patients brain during surgery, to avoid an injury to the eloquent cortex. Motor cortex detected by fMRI was confirmed via direct electrical stimuli by the surgeon.

Results: We demonstrated the primary motor cortex activation of all patients by fMRI and no motor deficit was detected postoperatively.

Conclusion: The primary motor cortex is structurally distorted in patients with brain tumors. If variations in the location of the eloquent cortex is to be considered, fMRI takes on an important role in demonstrating the true cortical position preoperatively with a great sensitivity. Stereotactic navigational systems seem to increase the success of fMRI.

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